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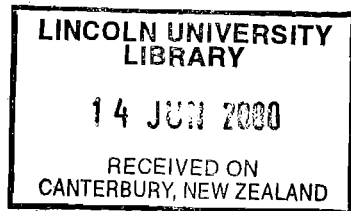
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AN ECONOMETRIC STUDY OF
THE NEW-ZÉALAND PIG-MEAT MARKET

A THESIS
SUBMITTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE
OF
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By
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Abstract of a Thesis Submitted in Partial Fulfilment
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AN ECONOMETRIC STUDY OF THE NEW ZEALAND
PIG-MEAT MARKET

by

M. J. Horn

This thesis describes an econometric investigation of the New Zealand pig-meat market over the period 1969 to 1979. The objective of the study is to provide policy-makers within the pig industry with a model of their industry that can be used to improve their ability to anticipate and respond to problems facing the industry. In particular, the study is concerned with providing policy-makers with a tool which can be used to improve their ability to reduce instability in the pig-meat market.

The transition from dairy by-product to grain ration feeding of pigs appears to have aggravated price and production instability in the industry and this problem is now a major concern of policy-makers.

This study describes the impact of the transition from dairy by-products to grain ration feeding of pigs as well as the causes and consequences of the associated increase in production and price instability. A 20 equation model of the market is specified that describes production, consumption, price formation, imports, exports and stock changes at various levels of disaggregation. This model is estimated using quarterly data for the period 1968 (fourth quarter) to 1979 (second quarter) and the two stage principal components estimating procedure. The estimated model is evaluated using simulation analysis.

In most respects the performance of the model described in this study is satisfactory. It is able to reproduce cyclic behaviour when all of the exogenous variables are held at a fixed level. These cycles are convergent with a mean length of approximately 3.5 years. Although the model does have some problems associated with it, it is useful to policy-makers in its present form. Model forecasts should be accurate enough to improve policy-makers' ability to predict many of the important market variables. The model should also prove useful in evaluating the implications of alternative future scenarios as well as the impact of alternative policy decisions on the market.

The staff of the Pork Marketing Board have already begun to use the model as an aid to policy making in the industry. Over the last nine months the model has primarily been used to provide quarterly forecasts and to evaluate the impact of alternative scenarios (e.g. increases in feed-grain prices) in the slightly longer term. Interest is also being shown in using the model to evaluate alternative policies under consideration by policy-makers. Research currently underway should help to overcome some of the problems associated with the model and, therefore, extend its usefulness as a policy tool.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

In any economy characterised by imperfections and distortions it is unreasonable to expect the unrestricted workings of any one market to maximise the welfare of its actual and potential participants. It is possible, under certain conditions, to devise economic policies that will improve aggregate welfare. Some of these policies will enhance the operation of the market by removing imperfections, while others will act to offset the impact of other distortions in the economy. However the welfare impact of economic policy is usually subject to considerable uncertainty. There is a risk that policy-makers, who act in a political environment, will make economic decisions that result in a welfare loss. This risk is high when the market has many of the characteristics of perfect competition and when policy-makers do not have access to reliable quantitative estimates of the likely impact of alternative decisions.

Policy-makers, especially at the industry level, often have only an incomplete database and intuitive "models" of the behaviour of market participants to work with. Under these circumstances it is possible that intervention in the market will not produce the desired effect. For example, there is good evidence to suggest that the operation of the Basic Minimum Price scheme has failed to provide price support to pig farmers.¹ Therefore, even when policy-makers are not influenced by special interest groups, it may be very difficult for them to identify policies which will improve economic welfare. When the influence exerted by different

1. This issue is discussed in detail in Chapter Seven.

market participants is uneven there is an increased risk that a given policy decision will not increase welfare.

The author has noted elsewhere the danger that policy-makers in the New Zealand pig industry will over-react to "problems" perceived by producers and introduce strongly interventionist economic policies which will compromise the allocative efficiency of the market for highly uncertain gains.² That paper stated:

"It is my belief that the allocative efficiency of the market can be improved, and the need for market intervention by producers minimised, with the aid of an accurate and credible computer based mathematical model of the market".³

This thesis has developed out of that belief.

1.2 Objectives of The Thesis

The New Zealand pig-meat market has many of the characteristics of a perfectly competitive market. However, the efficiency of this market is seriously constrained by the lack of "perfect information". Inadequate information concerning probable future prices is a significant market imperfection which, in combination with other factors, causes market instability and resource misallocation.

Like many agricultural sectors in New Zealand, producer boards (in this case the Pork Marketing Board (PMB) and Pork Industry Council (PIC)) have considerable power to make economic policy at the industry level. These boards can, and usually do, have an important influence on the efficiency of the markets in which they operate. As we shall see, there is considerable potential to improve the efficiency of the pig-meat market

2. M. J. Horn, Computers as an Aid to Pig Marketing in New Zealand, a paper presented at the 49th Congress of ANZAAS, Auckland, New Zealand, January 1979.

3. *Ibid.* p.2

despite its predominately competitive character. However, there is also considerable potential to contrive interventionist economic policies that result in an aggregate welfare loss. Given that both the Council and the Board are very sensitive to producer interests, and that both organisations act on the basis of intuitive "models" of market behaviour without an accurate or comprehensive database, it is unlikely that either body is in a position to make decisions which can be expected (given an acceptable variance) to produce aggregate welfare gains on a consistent basis. Simply put, these bodies do not have the "tools" appropriate to their policy-making function. In this case the appropriate "tool" is information; estimates of future movements in important market variables and estimates of the likely impact of alternative policy actions are the "tools" appropriate to decision-making at the industry level. Providing the right sort of information should act to improve the efficiency of the market as well as the quality of the producer boards' policy responses.

The objective of this study is to provide policy-makers in the pig industry with a quantitative description of their industry that is usable, credible and sufficiently accurate to improve their ability to anticipate and respond to problems facing the industry. This objective will be achieved by building an econometric model of the pig-meat market that can be used to forecast important market variables and estimate the impact of alternative policy decisions on these variables.

1.2.1 Potential Benefits of the Model

At present, decision-makers are forced to rely on intuitive models of the industry to define the relationship between variables of interest, and a mixture of incomplete statistics

and subjective judgements to provide values for these variables. The construction of an econometric model of the pig-meat market has the potential to improve policy-making within the industry in the following manner:

- (a) By providing policy-makers with complete, timely and accurate data on the important economic variables. In order to construct a model of this type these variables have to be identified and time series for all of these variables collected. Difficulty in obtaining these data has prevented its use in the past. Of their 42 time series used in this study, 16 were available from published sources, 19 were obtained from primary sources held by various government and quasi-government agencies, and the remaining seven were obtained directly from primary sources in the private sector. However, for any database to be useful it must be credible, accurate and timely as well as being available. Appendix A discusses the accuracy of the data available to the industry, and the data included in the model. The description of the data given in Appendix A enhances its value. Users need to know exactly what each series represents, where the weaknesses in the database are, and what assumptions were made to overcome data deficiencies. The clear identification of weaknesses in the database and focussing of attention on the nature and importance of these weaknesses has already prompted producers' representatives to take some action to improve the database.
- (b) Understanding of the important interactions within the market should be enhanced. Initially understanding should be improved as a result of

the detailed and quantified description of the market given by the model. The model incorporates a large number of variables in a complex system of interactions. This type of description of the market encourages appreciation of the complexity and nature of these interactions. Model users are encouraged to consider the effects of a wide range of influences on the market and to trace these effects within a consistent framework even though these effects may involve long, and reasonably complex, chains of causality.

Application of the model to policy problems will also enhance policy-makers' understanding of interactions in the market. The model provides an extra voice in the decision making process. An important characteristic of this "extra voice" is that its assumptions and logic are explicit. If policy-makers disagree with the model's results then they are encouraged to make their own assumptions and logic explicit also. This forces policy-makers to consider their own implicit "models" in greater detail and is likely to lead to some reformulation of these implicit "models". Understanding should also be increased when policy-makers use the model to simulate the effects of various policies on the market. This type of "what if" approach involves the policy-maker in a fairly intimate interaction with the model. This type of interaction is likely to make the policy-maker more aware of the total effect of a given exogenous change on all of the endogenous variables.

- (c) The model's ability to provide a consistent set of forecasts for all of the important endogenous variables for each quarter should improve policy-makers' ability to anticipate problems and therefore improve the timing of policy responses. There can be a trade-off between the accuracy with which a problem is diagnosed and the timeliness of the policy response. To delay a response until the problem can be more accurately defined may mean that the problem is compounded. To delay may also mean that the policy response is less effective or even wrong (especially when counter-cyclical policy measures are being considered). On the other hand, a quick response may not allow for an adequate analysis of the problem and may therefore be incorrect. Accurate forecasts help to remove this conflict between accuracy of diagnosis and timeliness of response.
- (d) The model can be used to estimate the impact of alternative policy decisions. The model will produce a consistent set of estimates for the endogenous variables given values for the exogenous and policy variables (where a policy variable is defined as an exogenous variable that can be directly manipulated by the decision-maker). Policy-makers can set alternative values for policy variables (which represent alternative policies) and use the resulting model estimates of the endogenous variables to evaluate these alternative policies. This is known as the "policy simulation" approach to policy analysis and has distinct advantages over alternative approaches which require some

knowledge of the policy-makers' welfare preferences or his particular targets.⁴ Policy makers have already used the model in this way to assess the likely impact of alternative levels of BMP (i.e. basic minimum farm prices set by the Board) on other important market variables.

- (e) Finally, the model can be used to provide information that can be used to improve the workings of the market. The pig-meat market conforms closely to assumptions of the perfectly competitive model with the notable exception of the assumption concerning "perfect information". It is arguable that the provision of information should be the major economic policy function of the Board. Information has many of the characteristics of a public good and there is reason to believe that collective action is required to produce the optimum amount of market information in an industry that is characterised by a large number of small producers. If the model can supply reasonable forecasts for the important market variables at reasonable cost, it can be used as a policy instrument as well as a policy tool.⁵

To summarise, the development of an econometric model of the pig-meat market has the potential to improve policy formulation

4. For a discussion of alternative approaches to the use of econometric models to evaluate the effects of alternative economic policies see T. H. Naylor, "Policy Simulation Experiments with Macroeconomic Models : The State of the Art", American Journal of Economics, Vol.42, No.2, May 1970, pp 263-271.

5. The model can be described as a policy instrument when it is used to influence the behaviour of market participants directly whereas it is a policy tool when it is used to

within the industry by improving the data available to policy-makers, enhancing the understanding of the important interactions within the market, and improving the ability to forecast values of the important market variables and to evaluate the impact of alternative policy actions on these variables.

1.2.2 Criteria for Judging the Acceptability of the Model to Policy-Makers

The primary objective of this study is to improve policy making in the pig industry. The development of an econometric model of the market has the potential to achieve this objective. Therefore the realisation of the five potential benefits of model building listed above represents an intermediate objective of this study.

The primary objective noted above will not be met unless the model is actually used as an input into the decision-making process. Therefore, the model has to be acceptable to policy-makers. For the model to be acceptable it must meet three criteria:

- (a) The model must be credible to policy-makers. The model's credibility is likely to be enhanced if the specification of the model coincides with policy-makers' conceptualisation of the market, if the model is reasonably reliable and accurate, and if the policy-maker is familiarised with the limitations of the model.
- (b) The model must be useful (i.e. provide the information required by the policy-maker). For the model to meet this criterion the

variables that the policy-maker can influence directly (i.e. policy variables or instruments) and the variables that he wishes to influence but can only do so indirectly (i.e. objectives), must be included in the model.

- (c) The model must be usable. The model will be usable if the data required to operate the model is available on a timely and uninterrupted basis, and the results are available on a regular basis prior to the decisions that require them.

Meeting these criteria must also be accepted as an objective of this study given their importance in determining whether or not the model is actually used.

1.3 Outline of the Study

This study is intended to provide policy-makers in the New Zealand pig-meat industry with a decision making tool. However the development of this type of tool can not occur in a vacuum. The demand for this type of tool results from the desire of policy-makers to "solve" specific "problems" perceived by market participants. Before the model can be usefully and correctly specified it is necessary to identify the objectives of building the model, to have a clear statement of the type of problems the model will be used to overcome, and to have an accurate description of the market to be modelled.

Section 1.2 identified the objectives of this study. Emphasis was placed on the applied nature of this research and therefore the need to provide policy-makers with the type of information that they require for forecasting and policy analysis. Chapter Two describes recent developments in the New Zealand pig-meat market, which has undergone important structural changes over the last 15 years. This chapter provides background to

the detailed descriptions of the structure of various components of the market developed in later chapters, as well as background to the problems currently facing the industry. Chapter Three discusses the major problem perceived by pig producers and, to a lesser extent, other market participants; market instability. This fundamental problem adversely affects the efficiency of the pig-meat market. Chapter Three identifies the causes, consequences and cures of instability in the pig-meat market.

Chapters Four to Nine describe the econometric model developed in this thesis in detail. Chapter Four describes the entire model in general terms (giving an "overview" of the workings of the market in its entirety) and the choice of estimation technique. The model is simultaneous with 22 equations (18 of which are behavioural), and has been estimated using two-stage principal components. Chapters Five to Nine inclusive describe each of the 5 "blocks" of behavioural equations in the model; consumption, farm to retail price margin; farm price, production and international trade. These chapters describe each of the behavioural equations in the model in detail following the methodology of econometric research; each equation is specified and estimated, and the parameter estimates are evaluated. Brief literature reviews are included in each chapter and, where appropriate, the policy implications of the results are discussed.

A detailed treatment of the specification of each equation in the model was considered necessary because it enables a critical examination of the theoretical foundations of each equation. This enhances the understanding of the behavioural relationships in the model and provides the necessary foundation for improving and, ultimately, re-estimating the model.

Chapter Ten evaluates the validity of the complete model using simulation analysis. The stability of the model is

evaluated along with the static and dynamic properties of the model both within and beyond the sample period. Chapter Eleven is the concluding chapter. It discusses the extent to which this study has met the objectives set out in this chapter, the developments needed to improve the model, and the applications of the model in its present form.

CHAPTER TWO

RECENT DEVELOPMENTS WITHIN THE NEW ZEALAND PIG - MEAT MARKET

2.1 Introduction

Pig production in New Zealand has undergone a radical transformation in the last 15 years as a response to changes in dairy processing technology which have resulted in a substantial decline in the quantity of dairy by-product available for pig feeding. The declining availability of these relatively cheap by-products has forced pig producers into a heavy reliance on grain feeding. Because of the competitive nature of the industry, these fundamental changes in its external environment have resulted in considerable structural adjustment within the industry itself. This chapter describes these changes and, in very broad terms, the characteristics of the industry that have emerged in response.

2.2 Changes in Dairy Processing Technology and Their Impact on the Dairy-Pig Production Regime

Prior to the mid 1960's pig production in New Zealand was predominantly a relatively low cost activity closely associated with butter and cheese production. Butter was manufactured from cream separated from whole-milk on the farm. The residual (skim-milk), which had a zero opportunity cost for most dairy producers, was available for animal feeding. This skim-milk (and, to a lesser extent, the whey produced in dairy factories as a by-product of cheese manufacture) was the predominant source of nutrients for pig feed. Therefore pig production was closely associated with dairy production, either as a non-specialist activity

practised on dairy farms (in association with on-farm separation of milk), or as a specialist activity utilising the by-products of dairy factories. A small proportion of total production was in the hands of producers utilising other types of pig feed (e.g. city food wastes).

During this period, pig production was dominated by dairy farmers who operated a large number of small, non-specialist pig production units. These units were characterised by a relatively low level of productivity and a distinctly seasonal production pattern coincident with the seasonal pattern of dairy production. There are indications that dairy producers saw pig production as an inferior activity; using the revenue from pig production to supplement low incomes from cream sales, and reducing pig numbers as soon as an acceptable income was available from dairying. Yandle makes the observation that during this period "pig numbers have tended to fluctuate inversely with the price of butterfat".¹

Improvements in dairy processing technology which enabled dairy factories to recover more saleable dairy products from a given quantity of whole-milk gradually eroded this historic link between pig production and dairy production. The gradual increase in tanker collection of whole-milk (which accompanied the increased production of milk powders) resulted in a corresponding decline in the on-farm separation of whole-milk. Table 2-1 shows the proportion of suppliers to dairy factories supplying whole-milk over the period 1959/60 to 1977/78

1. C. A. Yandle, An Econometric Study of the New Zealand Meat Market, M.Ag.Sc. Thesis, Lincoln College, University of Canterbury, 1968, p.15.

Table 2-1

Percentage of Suppliers Supplying Whole-Milk to
Dairy Factories by Island, Selected Years 1959/60-1977/78

<u>Year</u>	<u>North</u>	<u>South</u>	<u>Total</u>
1959/60	38	14	33
1965/66	75	20	67
1969/70	83	33	77
1970/71	85	39	80
1971/72	87	42	82
1972/73	91	50	87
1973/74	93	60	90
1974/75	95	67	93
1975/76	97	72	94
1976/77	97	82	96
1977/78	98	87	97

Source: New Zealand Dairy Board, Farm Production Reports
(selected years).

The decline of on-farm separation of whole-milk was well advanced by the 1969/70 dairy season when 77 percent of dairy factory suppliers supplied whole-milk. As progressively more dairy factories utilised skim-milk to produce milk powders, this hitherto primary source of pig feed was virtually eliminated. With the development of new products which utilised whey, the availability of this source of pig feed also started to decline.

It is difficult to be precise about the chronology of the decline in the availability of dairy by-products as a source of pig feed. Although a detailed description of the supply of dairy by-products during this studies sample period is given in Appendix A, no comparable figures are available for the period before 1968. Data collected from pig producers

concerning their source of pig feed was not collected by the Department of Statistics prior to 1977. The figures presented in Appendix A indicate that the supplies of dairy by-products declined dramatically through the sample period (1968 to 1979). However, the figures in Table 2-1 also indicate that much of the decline in on-farm separation of whole-milk had occurred prior to the start of our sample period (i.e. prior to the 1969 season). An examination of the seasonality pattern in pig production also indicates that the dairy influence had been significantly reduced by 1969. Therefore, although the historical relationship between dairy and pig production had been almost completely eroded by the end of the 1960s, the availability of dairy by-products is likely to have influenced pig production well into the 1970s. This conclusion is supported by the figures in Table 2-2 which indicate that, as late as June 1978, 15.8 percent of all holdings (with approximately 16.7 percent of the total pig herd) still used dairy by-products as a primary source of pig feed.

2.3 The Impact of the Decline in Availability of Dairy By-Products on the New Zealand Pig-Meat Market

The decline of dairy by-products as the primary source of pig feed has had significant consequences for the entire pig-meat market. Dairy by-products were an exceptionally cheap source of pig nutrient and their declining availability has forced pig producers to use relatively expensive grain-based rations as the predominant source of pig feed. Table 2-2 shows the relative importance of various types of pig feeds as at 30 June 1978. In contrast to the relatively low proportion of holdings feeding dairy by-products, 41.6 percent of all holdings (with approximately 60.6 percent of the total pig herd) used some type of grain based ration as the primary source of pig feed. These figures probably under-estimate the importance of grain as a source of nutrients fed to pigs because of the use of grain as a supplement feed in other categories.

Table 2-2

Pig Feed Used by Number of Holdings and Herd Size
as at 30 June 1978 (As Proportion of Total)

Number of Pigs in Herd size Group	% of Total Herd	Proportion of Holdings Feeding More Than 60% of Stated Feed						
		Barley	Maize	Compound Ration	By-Product	Garbage	Other	Total
1 - 19	4.2	15.7	2.4	13.5	14.9	25.7	27.5	100.0
20 - 99	10.6	33.2	4.8	23.7	19.1	4.7	14.4	100.0
100 - 499	30.0	32.9	4.3	29.4	15.3	7.3	10.7	100.0
500 - 599	18.5	28.2	4.8	28.2	17.7	8.9	12.1	100.0
1,000 - plus	36.7	24.4	12.2	21.9	17.1	17.1	11.0	100.0
Total	100.0	21.0	3.2	17.4	15.8	19.5	22.9	100.0
WEIGHTED TOTAL*		28.2	7.2	25.2	16.7	11.6	12.2	100.0

Source: Department of Statistics, Agricultural Statistics 1977/78 (unpublished)

* Total proportion of each "holdings by feed type and herd size" group weighted by the proportion of the total herd in each herd size group. This gives an approximate measure of the importance of each feed in determining total production.

The transition from dairy by-product to grain-based rations has had a major impact on the pig-meat market. The remainder of this chapter discusses this impact under four major headings, the structural impact on the production of pig-meat (specialisation, concentration and location), the impact on output (stability, trend and level), the impact on the relative size of the markets quantity aggregates, and the impact on the industry's organisational structure.

2.3.1 Structural Impact on Production - Specialisation, Concentration and Location

The declining availability of dairy by-products has reduced the dairy-pig production regime from a dominant to a relatively minor rôle in pig-meat production. Traditional producers, with traditional production techniques, have been replaced by grain feeders with production techniques suited to a high cost input structure. This major change has had three main features; production has become increasingly specialised, concentrated, and has shifted away from dairying areas and towards grain producing areas. This type of structural adaptation has allowed the level of output to be maintained (despite a drastic increase in costs), at least in part because of the increase in technical efficiency that the new production structure has encouraged.

Table 2-3 gives an indication of the degree of specialisation reached in the New Zealand pig industry and the change in the degree of specialisation between 1972 and 1978. These statistics are unavailable for the years prior to 1972 but it would be expected that, from the mid 1960s to 1972, the number of pigs on dairy farms would have declined while the number of pigs on pig farms would have increased.

Table 2-3

Total Number of Pigs by Farm Type
at 30 June 1972 and 30 June 1978

<u>Farm Type</u>	<u>% Total Pigs</u>	
	<u>1972</u>	<u>1978</u>
Pig Farming (1)	35.17	54.90
Dairy Farming (1) (3)	16.43	8.48
Dairy Farming with Other (2) (3)	6.88	3.14
Pig Farming with Other (2)	10.03	9.26
Mixed Livestock	17.95	9.51
General Mixed Farming	2.88	2.81
Other	12.66	11.90
	<u>100.00</u>	<u>100.00</u>

Source: Department of Statistics, Agricultural Statistics, 1971/72 (p.41) and 1977/78 (unpublished).

- (1) 75% or more of gross income is derived from stated activity.
- (2) 51-74% of gross income is derived from stated activity.
- (3) Income from pigs does not exceed 25% of gross income.

Most of the increase in the degree of specialisation in the pig industry indicated by Table 2-3 occurred in the early part of the period. By 1978 farmers who relied on pig production as their primary source of income owned 64.16 percent of the total pig herd whereas only 11.62 percent of the total herd was held on dairy farms.

It is highly likely that the decline in the supply of dairy by-products and the adoption of more specialist grain feeding production techniques has been accompanied by an increase in the average herd size. Table 2-4 indicates that a considerable concentration of production in the hands of the largest

producers has occurred since 1972. Again, this trend towards larger farms was probably well underway by 1972 but statistics prior to this period are unavailable.

Table 2-4

Total Pigs by Herd Size at
30 June 1972 and 30 June 1978

Herd Size (total pigs)	Percent	
	<u>1972</u>	<u>1978</u>
1 - 19	4.3	4.2
20 - 99	17.5	10.6
100 - 499	40.4	30.0
500 - 999	15.0	18.5
1,000 and Over	22.8	36.7
Total	<u>100.0</u>	<u>100.0</u>
Average number of pigs per holding	67.9	77.1

Source: Department of Statistics, Agricultural Statistics, 1971/72 (p.78) 1977/78 (unpublished)

Although there has been a considerable concentration of pig numbers in larger herds, the number of farmers with small herds is still large enough to have a considerable impact on the market.

The last major structural change in pig production that has occurred as a result of the decline in the supply of dairy by-products has been a geographical shift in production from the dairying areas towards the grain producing areas. Table 2-5 compares the geographical distribution of the total pig herd, the milking dairy herd and the important feed-grains for the years 1964 and 1978 as well as the distribution of

Table 2-5

Geographical Distribution of the Pig and Dairy Herds,
the Area of Maize and Barley Threshed, as
at 1964 and 1978 and the Total Population at 1971

STATISTICAL AREA	PERCENT OF NATIONAL TOTAL						
	1964			1971	1978		
	Cows ¹	Grain ²	Pigs ³	Population ⁴	Cows ¹	Grain ²	Pigs ³
Northland	13.0	0.3	15.9	3.3	11.4	1.0	3.4
Central Auckland	9.1	0.2	11.5	24.4	7.8	0.8	11.8
South Auckland, BOP	42.5	1.3	31.9	14.7	46.4	17.7	27.3
East Coast	0.7	7.8	1.1	1.6	0.2	4.1	0.7
Hawkes Bay	2.1	3.8	1.9	4.6	1.7	5.1	2.6
Taranaki	15.0	0.4	12.3	3.5	16.2	0.8	9.0
Wellington	9.4	12.2	10.7	19.3	8.7	14.2	12.5
NORTH ISLAND TOTAL	91.8	25.8	85.3	71.4	92.6	43.7	67.5
Marlborough	0.6	3.2	1.6	1.1	6.7	2.4	4.4
Nelson	1.6	1.8	3.7	2.4	1.8	0.9	3.6
Westland	0.8	-	1.5	0.8	1.0	0.03	0.2
Canterbury	2.7	63.2	5.5	13.9	1.9	42.5	16.7
Otago	1.1	5.2	1.3	6.4	0.9	5.4	4.1
Southland	1.4	0.7	1.1	3.7	0.9	4.9	3.3
SOUTH ISLAND TOTAL	8.2	74.1	14.7	28.3	7.3	56.1	32.5
NEW ZEALAND TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Department of Statistics, Census of Population and Dwellings 1971, Increase and Location of Population (p.16), Agricultural Statistics 1963/64 (p.27), Agricultural Statistics 1977/78 (unpublished).

1 For the 1964 season this figure refers to the number of dairy stock in milk, and for the 1978 season this figure refers to dairy cows in calf and in milk.

2 Total area of maize and barley for threshing

3 Total pigs

4 Total population at 1971 census

population recorded in the 1971 Census. The 1964 year would be representative of the geographical distribution of the pig herd when dairy by-product feeding was predominant. The herd was concentrated in the dairying areas; Northland, Central Auckland, South Auckland, Bay of Plenty, Taranaki and Wellington had 89 percent of the dairy herd and 82.3 percent of the pig herd. Canterbury, which produced 63.2 percent of the feed-grain had only 5.5 percent of the total pig herd.

By 1978 the geographical distribution of production had changed considerably compared with 1964. The pig herd has moved from the dairying areas to those areas that have a large proportion of either the grain area or the total population. Areas of large population have two advantages, they are a potential source of pig feed (i.e. food wastes) and they are the main market for pig-meat. Dairying areas with low populations and low feed-grain production (e.g. Northland) have experienced a dramatic decline in pig numbers. However dairying areas with either large populations (e.g. Central Auckland) or both large populations and large areas of feed-grains (e.g. Wellington) have tended to retain their pig population. Areas without a strong dairying history but with some areas of feed-grain (e.g. Otago) have increased their pig numbers. The most important increase in the relative size of pig population has occurred in Canterbury which has only a very small dairy herd, a large population and a very large production of feed-grains. This movement of the pig population appears to reflect a rational relocation of the industry that enables producers to either reduce costs (by moving closer to the source of feed) or to add value (by being closer to the market) or some combination of both.

Table 2-6 compares some selected characteristics of pig production in the North and South Islands. It demonstrates that South Island pig farms are smaller (with 65 percent of total pigs in the 20-999 size group compared with only 56

percent of total pigs in the same group in the North Island), and considerably more reliant on grain feeding than their North Island equivalents. This would suggest that South Island production is considerably more sensitive to changes in feed grain prices and that North Island production is more sensitive to fluctuations in the supply of dairy by-products. There is also likely to be a different seasonal pattern of production in each island.

Table 2-6

Comparison of Selected Characteristics
of North and South Island Pig Production
(Statistics are for June Year 1978 unless otherwise stated)

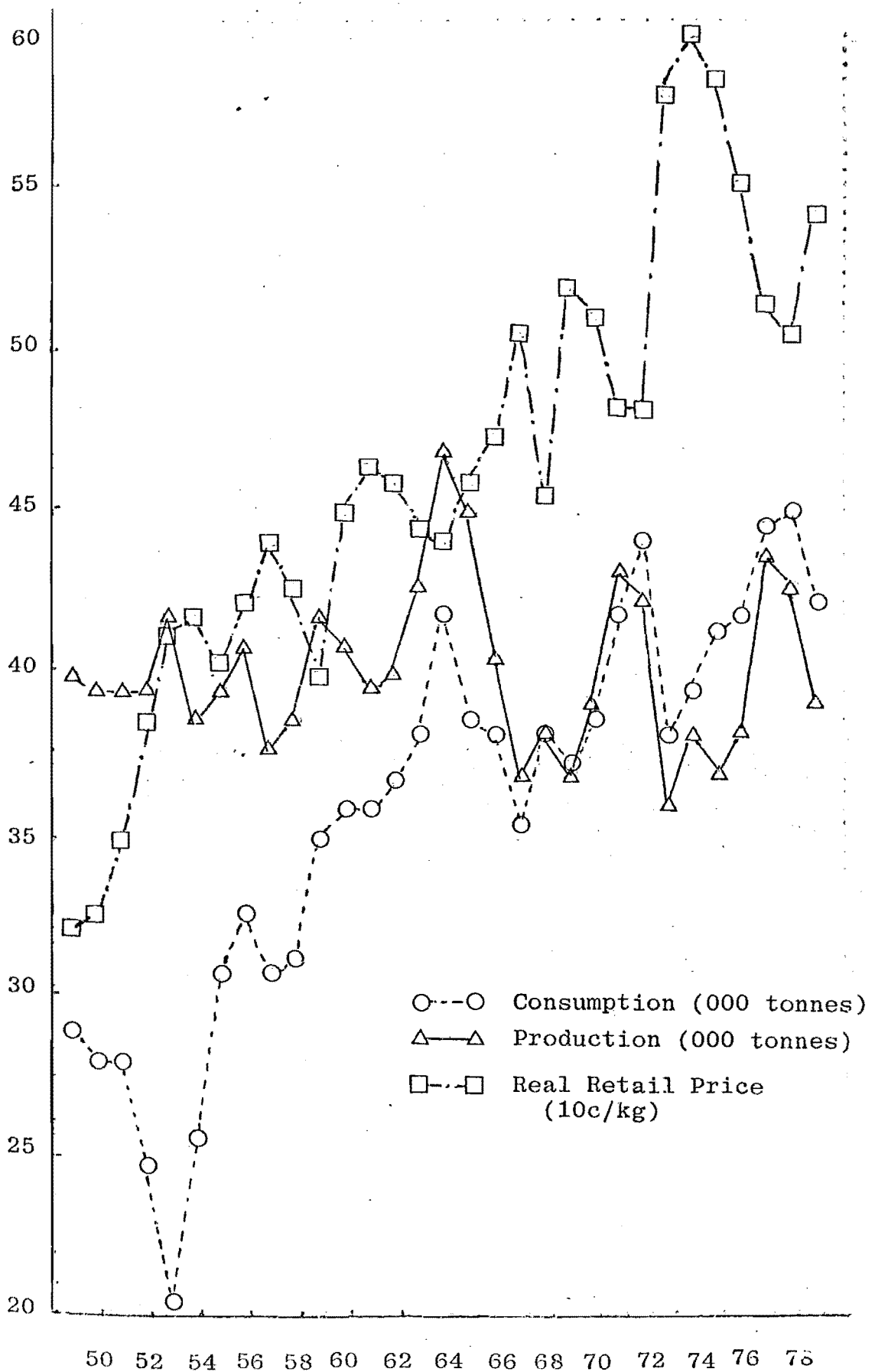
	<u>North Island</u>	<u>South Island</u>	<u>Total</u>
% National Herd in 1964	85.3	14.7	100
% National Herd in 1978	67.5	32.5	100
% Total holdings in New Zealand	64.0	36.0	100
% Total holdings in each island feeding:			
(a) more than 60% of either barley, maize or compound feed	34.0	55.0	-
(b) more than 60% dairy by-products.	21.0	6.0	-
Average number of pigs/holding	82.0	69.0	-

Source: Department of Statistics, Agricultural Statistics 1977/78.

An examination of the data indicates that there is very little association between the quarterly movements in total production in each island. When North and South Island production were regressed against each other using quarterly data from 1968 to 1972 the resulting R^2 was only 0.32.

Figure 2-1

Annual Production and Consumption of
Pig-Meat in New Zealand, 1949-1979



2.3.2 Impact on Output - Stability, Trend and Level

Figure 2-1 illustrates the annual movements in pig-meat production and consumption over the last 31 years. The figures used in this graph are a combination of figures from the Department of Statistics (up to and including 1970), and the figures used in this study (see Appendix A). Appendix A explains why the Department of Statistics figures for production and consumption are unreliable after 1970.

Prior to the mid 1960s, production was remarkably stable however from the mid 1960s onwards marked fluctuations appear in production. Table 2-7 compares three different measures of production instability for the earlier (1949-1962) and later (1966-1979) periods. The years 1963-1965 inclusive have been excluded from the analysis in order to use "typical" start and end values for trend fitting (1964 being an exceptional year and 1962 and 1966 being average years for the entire 1949-1979 period for the production series).

Table 2-7

Comparative Measures of Instability in the Production of Pig-Meat (1949-1962 and 1966-1979)

<u>Measure of Trend</u>	<u>Measure of Deviation from Trend</u>	
	<u>1949-62</u>	<u>1966-79</u>
5 Year Moving ¹ Average	3.2	5.0
Linear Time ²	2.0	5.6
Standard Deviation/Mean	2.9	6.8

1 For the periods 1951-1962 and 1966-1977: Calculated as:-

$$\left(\left(\sum_{i=1}^n |X_i - \hat{X}_i| / X_i \right) / n \right) * 100$$

where:

i = 1, 2 n; year

X_i = actual observation in period i

\hat{X}_i = centred 5 year moving average in period i

n = 12

2 Calculated as for 1 above except that:

\hat{X}_i = estimated linear trend value in period i

n = 14

Although different measures yield slightly different answers, it would appear that production instability in the 1966-1979 period was approximately double that for the 1949-1962 period.

The link between the decline in dairy by-products and the stability of production is likely to be causal rather than coincidental. Skim-milk available on the farm had a very static "cost" and therefore the variability in profitability was associated with variations in productivity or output prices only. However, with a change to grain-based rations, profit stability was also susceptible to variations in the price of feed grains and other ration ingredients (notably animal proteins). These major input costs have been highly unstable over the 1970's. The instability problem is treated in detail in Chapter Three.

A striking feature of the production series illustrated in Figure 2-1 is its lack of trend movement. When a trend line is fitted to the production series for 1949-1979, no distinct trend is evident (the t statistic associated with the trend parameter is -0.06 which is highly insignificant). The average level of production for the 1970s is identical to that of the 1950s and only two percent below that for the 1960s. Given the evidence presented in Section 2-3-1, the lack of a downward trend in production indicates that the decline in the numbers of traditional producers has been completely offset by increases in productivity and an increase in the number of producers (with larger herds) feeding grain based rations. This fact is not widely appreciated within the pig industry. The Department of Statistics production figures show a consistent negative bias after 1970 (see Appendix A) and they have erroneously reinforced the belief that pig-meat production is declining in response to rising costs.

The fact that average production levels have remained remarkably static over the transition to grain based production provides prima facie evidence that the higher

cost structure associated with this type of production has been fully offset by increases in productivity and output prices. Although only fairly crude measures of productivity are available they do show a dramatic improvement in the late 1960's and early 1970's. Probably the best measure of productivity in pig production is output per sow. Most of the fixed costs of production (e.g. housing) and a large proportion of the variable costs (e.g. labour, feed) occur in fixed proportion to sow numbers. Cost per pig marketed is therefore very sensitive to changes in output per sow. Costings calculated by staff of the PIC indicate that, within a fairly normal productivity range, sow costs per kilogram of pork produced can vary between 68 cents (low productivity) to 39 cents (high productivity).² The low productivity farmer is spending nearly half of his gross returns on these costs. Between 1957 and 1966 the average number of pigs marketed per sow per year was approximately 9.6, however for the 10 year period following 1966 this number has increased to 11.6³. Cross-sectional data indicates that efficient meal feeding units can achieve output in excess of 20 pigs marketed per sow year.⁴

2.3.3 Impact on the Relative Size of the Important Market Quantity Aggregates

The decline in the availability of dairy by-products has been associated with an important shift in the relative importance of the market quantity aggregates; consumption, production, imports and exports. Figure 2-1 illustrates the increasing importance of domestic consumption in the final demand for pig-meat over the period 1949-1979. Domestic demand has shown a strong upward trend throughout the period in the face of a virtually static domestic supply. During

2. Pork Industry Council, New Zealand Production and Management Manual, p.7 - Production.
3. Reported in the Annual Report of the Pork Industry Council and based on Ministry of Agriculture and Fisheries slaughter figures and the Department of Statistics sow numbers.
4. Pork Industry Council New Zealand Pig Production and Management

the 1950s domestic demand averaged only 70 percent of the total demand for pig-meat produced in New Zealand (the balance going to exports). Throughout the 1950s and early 1960s exports were a regular and important feature of the market whereas imports of pig-meat were insignificant (see Table 2-8). This situation changed in the mid 1970s when domestic demand started to exceed domestic supply. During the 1970s domestic demand averaged in excess of 100 percent of domestic production and the industry changed from being a net exporter to a net importer of pig-meat.

Table 2-8

Net Exports of Pig-Meat by Value, Selected
Years 1950-1978, (\$000 at Current Prices)

<u>Year</u>	<u>Exports</u> (\$ fob)	<u>Imports</u> (\$ cif)	<u>Net Exports</u> (\$000)
1950	2,450	-	2,450
1955	3,622	-	3,622
1960	1,610	-	1,610
1965	2,350	...	2,350
1970	842	5	837
1975	770	1,714	- 944
1976	842	3,465	-2,623
1977	1,189	1,171	18
1978	1,588	265	1,322
1979	1,399	2,593	-1,194

Source: Department of Statistics, External Trade Exports, External Trade, Imports for selected years to 1965 and External Trade of New Zealand (exports and imports), quarterly figures published in supplements to the MAS 1970-1979.

... Under \$500,000

These changes may have contributed to increasing production and price instability in the pig-meat market. Figure 2-1 indicates that real domestic retail prices have shown a strong upward trend over the last 30 years. During the 1950s retail prices were relatively low and exports relatively large. It is quite probable therefore that domestic and export prices for pig-meat were similar and, therefore, that the export price acted as an effective floor price in the domestic market. This would tend to dampen the price and quantity fluctuations associated with any domestically produced exogenous shock. However, as domestic consumption increased export volumes declined to a very low level and it is likely that export prices were too low (relative to domestic prices) to act as an effective floor on domestic price movements. During this period the domestic market would be particularly susceptible to domestically produced exogenous shocks.

If domestic prices continue to increase, imports will become even more competitive and import prices will begin to act as a ceiling on domestic price movements. Downturns in domestic supply will be partially offset by an increase in imports rather than being fully reflected in an increase in domestic prices.

Lack of data for the period prior to 1968 prevents a close examination of the argument noted above. Analysis of the data presented in Figure 2-1 does indicate that both price and production instability increased in the latter period. The average absolute percentage error for the real retail price based on a linear trend for the 1966-79 period is nearly 50 percent higher than that recorded for the 1949-62 period. The results presented in Chapter Nine also indicate that, at least during the 1970s, both exports and imports were sensitive to domestic as well as foreign prices. However, an analysis of the consumption series illustrated in Figure 2-1 indicates that consumption instability was nearly twice as high in the earlier compared with the latter period. This would suggest that a number of other factors influenced consumption stability in the earlier period. For example, it is possible that

exogenous shocks to demand were larger in the earlier period. Given the importance of exports, these shocks could have had a major influence on consumption without changing either domestic production or prices substantially. Other factors are also likely to have been important in explaining the increased production and price instability demonstrated by the market. These are examined in detail in Chapter Three.

2.3.4. Impact on the Industries Organisational Structure

The separation of dairy and pig production resulted in the disjunction of the organisational structure of the two industries. Prior to 1974 the affairs of the pig industry were handled by sub-committees of the New Zealand Dairy Board. As pig production became established as a predominantly independent production activity, pig producers desired greater autonomy from the Dairy Board. The first major step towards this autonomy was the establishment of the Pork Marketing Board and associated Pork Industry Price Stabilisation Committee by the Pork Marketing Board Regulations 1973. Full autonomy was achieved with the establishment of the Pork Industry Council by the Pork Industry Council Act of 1974. In practice the Board and Council work very closely together and share members as well as executive and secretarial staff. Both the Board and the Council are dominated by producer interests.

The principal functions of the Council are to:

"organise the orderly development of the pork producing industry.... assist in the organisation and development of the orderly marketing of pigs ... (and to) increase efficiency (within the industry)".⁵

5. Pork Industry Act 1974, p.7.

Most of the Council's activity has been directed at improving the efficiency of pig production. The Council operates an extensive, non-commercial advisory service to producers, an on-farm performance testing service and a boar performance testing station (both of which help producers to identify the economic characteristics of potential breeding stock), the National Pig Breeding Centre (which produces breeding stock of high genetic merit for sale), funds independent research projects, and is responsible for the publication of an industry magazine. However, the Council's main policy concern has been to try and stabilise the pig-meat market. This concern is a direct response to increasing producer discontent with fluctuating prices and incomes.

The main function of the Board is:

"to assist in the orderly marketing of pigs and to promote greater efficiency in the marketing of pork meat".⁶

The Pork Marketing Board Regulations direct the Board to achieve this objective by fixing

"basic minimum prices for various classes of pigs"⁷

and empowers it to levy producers:

"to promote the sale and consumption ... of pork meat (and to finance) the acquisition by purchase or otherwise of pigs or pork meat (and) the disposal by sale or otherwise of pigs or pork meat."⁸

These regulations give the Board considerable power to intervene in the market to levy producers, set prices, and

6. Pork Marketing Board Regulations 1973, p.4.

7. Pork Marketing Board Regulations, Amendment No.2 (1976), p.2.

8. Pork Marketing Board Regulations 1973, p.5.

to acquire and dispose of pigs. Guidance in determining the degree of this intervention is given in the regulations which define the functions of the Price Stabilisation Committee as:

"to recommend to the Board such basic prices for specific classes of pork meat as may be considered necessary to ensure the development and continuation of a stable pig production industry operating efficiently at a level necessary to provide sufficient pork meat to meet the requirements of the domestic market ..."⁹

To date, the Council and the Board have been primarily concerned to stabilise the market by the operation of a floor price scheme (the "Basic Minimum Price" (BMP)), in combination with selective promotional and disposal policies. This strategy is described in detail in Chapter Three.

2.4 Summary

Advances in dairy processing technology and a corresponding decline in the availability of dairy by-products as a source of pig feed has had a dramatic impact on the structure of the pig industry throughout the 1960's and into the 1970's. The most significant structural change has been the decline of the dairy-pig production regime. The change from dairy by-product to grain-based ration feeding has resulted in the decline of pig production on dairy farms and an increase in the predominance of specialist pig farms which tend to be larger, more efficient, and concentrated in areas close to either supplies of feed-grain and/or densely populated areas. These fundamental structural changes have been achieved without any significant change in the level of total domestic production. Increases in productive efficiency and a strong upward trend in real pig-meat prices

9. Ibid, p.5

throughout most of the period has sustained output levels despite the switch to grain-based pig rations which have increased the cost of pig production.

However, despite a strong upward trend in real retail prices of pig-meat, the domestic consumption of pig-meat has continued to expand through the 1949 to 1979 period. The continuous expansion of domestic demand in the face of no trend increase in supply has resulted in a strong positive trend movement in retail prices, a reduction in exports, and the initiation of an import trade. During the 1949 to 1979 period the industry changed from a net exporter to a net importer of pig-meat and the sum of exports and imports fell as a proportion of the total domestic market.

The final major impact of the declining dairy-pig production regime has been the disjunction of the organisational structure of the two industries. The establishment of the Pork Marketing Board in 1973 and the Pork Industry Council in 1974 gave the industry complete autonomy from the Dairy Board. The major concern of the new organisational structure has been to try and "organise the orderly development of the pork producing industry" in the wake of the fundamental structural changes described in this chapter. In particular, the new organisation's main policy interest has been to try to devise an effective stabilisation strategy. Chapter Three discusses the problem of instability in detail.

CHAPTER THREE

THE PROBLEM - MARKET INSTABILITY

3.1 Introduction

The evidence presented in Chapter Two demonstrated the marked increase in production instability associated with the move towards the grain feeding of pigs. That chapter also noted the concern of the industry organisation about instability in the market. There is unanimous agreement that market instability is the major problem facing the New Zealand pig industry. Producers, and to a lesser extent processors and traders, are primarily concerned about fluctuations in profitability which is manifest in a concern over fluctuations in prices and production.

This chapter discusses the problem of market instability in detail : its causes and consequences, the present industry response to instability, and the economic justification for the type of response recommended in this thesis. This taxonomy is similar to that recommended by MacBean:

"before attempting to prescribe a cure, one should, in general, be sure: (a) that the patient really is sick, (b) that the causes are understood, (c) that the prescribed cure is not going to be worse than the disease."¹

Although market instability is the major problem facing the industry, there are other broader economic problems that will influence resource allocation between the pig industry and other industries in the economy. The New Zealand economy is characterised by a number of distortions

1. A. I. MacBean, Export Instability and Economic Development, University of Glasgow Social and Economic Studies, No.9, George Allen Urwin Ltd, London, 1966, p.341.

that are likely to reduce the size of a relatively "unprotected" industry like the pig industry. These distortions range from generalised measures that affect the balance between sectors in the economy (e.g. tariffs and quantitative restrictions) to measures that affect the balance of industries within the agricultural sector (e.g. government payments to farmers for the number of sheep and cattle on hand) to specific measures that affect the direct costs faced by pig producers (e.g. the ability of the Wheat Board to alter wheat prices which in turn effects the cost of feed-grain). Tariff protection and other government support for the pig industry is relatively minor (e.g. imports of pig-meat from Australia were placed on Schedule A in the original NAFTA Agreement). Although economy-wide distortions are likely to reduce the size of the pig industry it would require an extensive research effort to adequately quantify these effects. Even if the information were available, it would require central government action to remove or off-set these distortions. Given the incredibly slow progress that government has made in removing (or adequately off-setting) quantitative restrictions despite the considerable welfare advantage in doing so, it is highly improbable that Government would take the sort of action required to remove or off-set distortions facing the pig industry. On the other hand, market instability is perceived as the major problem by the industry and it is a problem that does not require central government action to solve; the industry's own organisation has all the power it needs to solve the problem itself. For these reasons, the economic problems affecting the industry resulting from distortions in other sectors or industries are ignored in this analysis.

3.2 Measuring Instability

There are two important issues that need to be addressed when measuring instability; which variable(s) should be measured and how much of the variation exhibited by the variable(s) can be described as instability?

There are a number of alternative variables that could be used to measure market instability (e.g. prices, quantities or incomes). Alternative measures are likely to give a different picture of instability in the industry. The negative correlation between prices and quantities in the same period will tend to moderate the impact of fluctuations in either variable on gross income for that period. The discussion in Chapter Two also noted that while production and price instability in the pig-meat market have increased, consumption was more stable in the 1966-79 period than the 1949-66 period.

Data limitations preclude a careful examination of the causes of consumption instability in the 1949-62 period. This study is primarily concerned with instability in the relative profitability of production because it is this instability that has the dominant effect on resource allocation. It is also of major interest to policy-makers in the industry (which is understandable given the small proportion of consumer expenditure spent on pig-meat). However, data inadequacies prevent an adequate analysis of the relative profitability of production prior to 1968. Therefore fluctuations in production have been used as a substitute for fluctuations in profitability. This does not mean that consumption instability is considered unimportant. Given the close association between domestic supply and demand, instability in any one variable is likely to be intimately (if not causally) related to instability in any of the others. Efforts to stabilise production and prices should remove a major cause of consumption instability.

Instability must be defined in relation to some trend value. Therefore, the first step in measuring instability must be to correctly identify the trend in any particular series. Given that the measure of instability should reflect the seriousness of the perceived "problem", and accepting that it is unanticipated changes that cause economic problems (i.e. fully anticipated changes are correctly reflected in production plans), then the trend should reflect expected

(or anticipated) values while "instability" should reflect unexpected changes (or deviations about the expected values). Therefore, the trend measure should be derived from some underlying behavioural hypothesis about how producers form expectations. However most empirical research has relied on relatively unsophisticated trend measures that imply very simplistic underlying behavioural hypotheses.²

Table 2-7 summarises the use of three indices to measure instability in production for the 1949-1962 and 1966-1979 periods. All three measures are based on simplistic behavioural assumptions. The centred five year moving average assumes that producers expect production in year t to be the simple average of production in periods $t-2$, $t-1$, t , $t+1$ and $t+2$. The "standard deviation/mean" and "linear" trends also assume that producers can form expectations about production in any period with the aid of unobservable (i.e. future) production levels. The former assumes that producers expect a fairly static relative profitability future, whereas the latter measure assumes that producers correctly anticipate and expect the given trend relative profitability future. The time periods used in all three measures (i.e. the five year moving average and the 14 year trend calculations) imply alternative time horizons used by producers in forming expectations. Obviously all three measures are very crude and it is erroneous to apply the same measures to different variables. However, some of the concern about the validity of these measures is reduced because the results presented in Table 2-7 give a fairly consistent picture of the relative importance of production instability for the two periods. All three measures indicate that production instability has nearly doubled. Given the difficulties outlined above it would be incorrect to try to conclude more from these results.

2. See for example, J. D. Coppock, International Trade Instability, 1977 and A. I. MacBean, Export Instability and Economic Development, 1966. For an excellent example of an explicitly behavioural measure of instability see O. Knudsen and A. Parnes, Trade Instability and Economic Development, 1975. Knudsen and Parnes derive a measure of income instability from M. Friedman's permanent income hypothesis (i.e. a measure of permanent (trend) and transitory (deviations) income).

3.3 Causes of Instability

Chapter One noted that, although the pig-meat market has many of the characteristics of the perfectly competitive model, its efficiency is seriously impaired by the lack of perfect information about future prices and that this (in combination with other factors) caused inherent market instability. This section discusses this proposition in detail. The influence of the transition to grain feeding on stability in the market is also considered.

3.3.1 Economic Friction, Imperfect Information and Instability

There are seven preconditions for perfect competition; a large number of buyers and sellers, individual buyers and sellers must face perfectly elastic supply and demand curves, a homogeneous product, freedom of entry and exit, an absence of all economic friction and perfect information. The New Zealand pig-meat market meets a number of these preconditions.

Pigs are farmed on over 6,000 holdings in New Zealand. Although 700 of these holdings produce over 60 percent of total pig production it would be fair to say that there are a large number of producers all of whom face perfectly elastic demand curves. There are six major purchasers of bacon weight pigs in New Zealand and 20 minor purchasers. The major buyers operate over a wide geographical area. Pork weight pigs are purchased primarily by butchers and supermarkets, or wholesale meat organisations servicing butchers. To be able to argue that individual processors or wholesalers were able to exercise any degree of monopoly or oligopoly power one has to maintain either that these firms act in collusion or that some geographical monopolies exist. Both of these conditions may exist to some degree, however it would appear that the market power of individual firms is fairly limited. The ability of producers to substitute between pork and bacon production at the margin

ensures that prices for these products do not move too far apart. The difficulty of effective collusion amongst a fairly large number of buyers is effectively increased because one of the largest purchasers of bacon weight pigs is a producers co-operative. Finally, the wide geographical distribution of the major companies and the ability of producers to transport live pigs to sale would place an effective limit on any particular geographical monopoly.

Apart from the distinction between pork and bacon pigs and between the three grades of pig, live pigs are a homogeneous product. Some bacon companies do actively promote their own brand of bacon, ham and small goods. Although pigs or pig-meat are not perfectly homogeneous it is extremely doubtful that the type of heterogeneity that does exist restricts competitive behaviour.

Freedom of entry and exit is a characteristic of pig production. Except for the very large capital-intensive farming systems, pig farming is very easy to either enter or exit providing a relatively small area of land is available.³ In fact a large number of producers enter and leave pig production over the length of any particular "cycle". Entry into processing and wholesaling is more limited than entry into production. However, there are a number of fairly small processors and a number of butchers (usually in country towns or on the fringes of cities) who cure their own bacon and ham. They are able to purchase pigs directly from farmers and have the animals slaughtered at local abattoirs.

The conclusion that competition is strong at both the wholesale and retail levels of the pig-meat trade is given considerable support by the findings of the Committee of Inquiry into the Distribution of Meat, Fish, Fruit and

3. For a discussion of low cost pig production techniques see C.N. Taylor, M. J. Horn, and R. McKenzie, Pig Farming for Peasants, Lakeside, April 1978.

Vegetables.⁴ Although the Committee did not extend their enquiries to include pig-meat, they did conclude that both wholesale and retail competition in the meat trade as a whole was strong. With respect to the wholesale meat trade the Committee concluded that:

"Competition is strong in the wholesale trade, with various types of wholesaler, independent as well as based on export works, competing for livestock and for a share of the retail trade. In addition, retailers buy extensively on the hoof, either individually or through various forms of buying agents such as butchers co-operatives. Some supermarkets also buy on the hoof ... the extent to which one wholesaler may be a major trader in any locality is offset by the ability of retailers in most districts to buy livestock and have it slaughtered on their behalf at an abattoir."⁵

With respect to the retail meat trade the Committee concluded that:

"Retail competition is very strong ... the advent of the supermarket in recent years, the operations of prepackaging and freezer pack firms together with the ability of any grocer or dairy to carry a few lines of frozen cuts ... provide the consumer with ample opportunity to get supplies and to shop around for the best price."⁶

These comments on both the wholesale and retail trade are as valid for the pig-meat trade as they are for the meat trade as a whole.

The first five preconditions for a perfectly competitive market discussed above are closely approximated by conditions in the pig-meat market. However, the final two preconditions an absence of economic friction and the availability of perfect information, are not approximated by conditions in

4. Report of a Committee of Inquiry into the Distribution of Meat, Fish, Fruit and Vegetables, March 1973, Government Printer, Wellington, 1973.

5. Ibid, p.48

this market. Economic friction exists because the biological lag in production prevents automatic adjustment of output levels to changes in prices. Imperfect information is also a problem because producers cannot accurately predict output prices, at the time when pigs are slaughtered, on the basis of information available when sows are mated. It is the absence of these two critical preconditions that results in inherent market instability and precludes the attainment of pareto optimality.

The simplest representation of the impact of the combined effects of economic friction and imperfect information is the recursive "cobweb theorem" representation of pig-meat market dynamics.⁷ This representation of a pig-meat market has been used by many authors as an explanation of an observed "hog cycle" (i.e. cyclic movements in the prices and quantities of pig-meat) in both England and the United States.⁸

In its simplest form, the cobweb model is only applicable when three conditions apply:

- (a) that at least one full period elapses before changes in production plans affect actual production;
- (b) the producer bases plans for future production on the assumption that present prices will continue,⁹ and

7. M. Ezekiel, "The Cobweb Theorem", Quarterly Journal of Economics, Vol. 52, February 1938, p.255-280.

8. See, for example, R. H. Coase and R. F. Fowler, "Bacon Production and the Pig-Cycle in Great Britain", Economica, 2: 142-67 May 1935; C.W. Dean and E. O. Heady, "Changes in Supply Response and Elasticity for Hogs", J. Farm Economics, Vol.40, November 1958, pp 845-60; A. A. Harlow, "The Hog Cycle and the Cobweb Theorem", J. Farm Economics, Vol.42, November 1960, pp 842-853.

9. However the Cobweb model is not restricted to the "naive expectation" representation of producers' price expectations. For example, see F. V. Waugh, "Cobweb Models", Journal of Farm Economics, Vol.46, November 1964, p.732-750.

- (c) there is pure (rather than perfect) competition, and prices are set by the supply available. Perfect competition is distinguished from pure competition by the additional assumptions of perfect information, freedom of entry, and the absence of economic friction.

The cobweb model demonstrates that, when these conditions are fulfilled and the market suffers an exogenous shock, production consumption and prices will tend to fluctuate around the static market equilibrium in either a continuous, divergent or convergent manner depending on the shape and relative slopes of the supply and demand curves.

The simple cobweb model can be extended to provide a more adequate representation of any particular commodity market. One of the most useful extensions is to include stocks in the model. In this case the simple cobweb structure:

$$C_t = f(P_t)$$

$$Q_t = g(P_{t-1})$$

$$C_t = C_t$$

where:

$$C_t = \text{consumption in period } t$$

$$Q_t = \text{production in period } t$$

$$P_t = \text{price in period } t$$

is extended to include stocks in an explicit price equation:

$$C_t = f(P_t)$$

$$Q_t = g(P_{t-1})$$

$$P_t = h(\Delta St)$$

$$\Delta St = Q_t - C_t$$

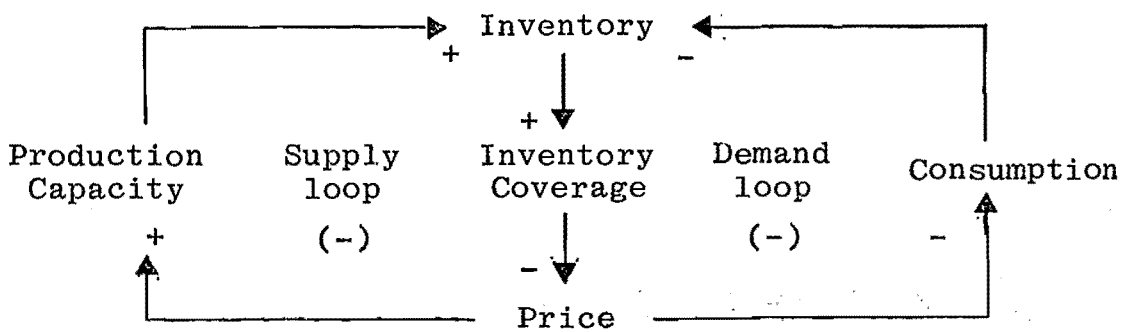
where:

$$\Delta St = \text{change in stocks in period } t$$

This type of extension to the simple cobweb model has been used by Meadows to explain a number of price cycles.¹⁰ Meadows' basic model structure is illustrated in Figure 3-1. Essentially the structure consists of two "coupled negative" feedback loops of supply and demand which act to adjust inventory to a desired level. Price changes are made by the holders of inventory when actual inventory levels (or "coverage") deviates from the desired inventory level.

Figure 3-1

Feedback Loop Structure of Meadows
Basic Commodity Production Model



Note: The plus or minus sign at the head of each arrow indicates the direction of the relationship between the two variables linked by that arrow (e.g. as price increases, consumption decreases - a negative relationship).

This basic structure was adapted by Meadows to represent the United States pig industry and the resulting model was then analysed using computer simulation. In this case the production capacity-inventory relationship is lagged. When the model is subject to an exogenous shock, it produces a production cycle which very nearly replicates the 4-year United States hog cycle.

10. D. L. Meadows, Dynamics of Commodity Production Cycles
Wright-Allen Press, Cambridge, 1970.

It is not surprising that Meadows basic model structure should simulate a production and price cycle very similar to that produced by the simple cobweb model. Like the simple cobweb model, cyclic instability in the Meadow model is produced by a combination of the production lag (economic friction) and farmers' failure to correctly anticipate future price levels (imperfect knowledge). For example, an exogenous shock that reduces consumption will result in an increase in actual inventories above the desired level and a reduction in prices. The reduction in prices will stimulate consumption which will tend to reduce actual inventory closer to its desired level. However, the fall in current prices lowers producers' forecasts of future price levels and therefore their desired capacity. After a production lag, reduced capacity results in reduced production, reducing inventory and increasing prices. If either producers correctly anticipate future prices (and therefore did not reduce their capacity in the face of the initial price reduction) or there was no production lag, the production and price cycle stimulated by Meadows would fail to materialise.

Although the New Zealand pig-meat market could not be adequately represented by either the cobweb model or the Meadows model, these simple representations highlight one essential point; that the existence of a production lag in combination with price expectations based on current prices will produce production and price cycles in an otherwise perfectly competitive market. The extensions of these basic model structures required to adequately model the real world will modify and complicate the underlying market dynamics illustrated in the simple models above. These extensions are described in detail in the next chapter. However, these modifications to the underlying market dynamics should not obscure the importance of economic friction and imperfect knowledge in generating market instability.

3.3.2 The Influence of Grain Feeding on Instability

The arguments presented above indicate that the pig-meat market has the necessary preconditions for market instability similar to that represented by the cobweb model. This instability has been described as "inherent" and is essentially endogenous. These preconditions would have been present throughout the post-war period yet the figures in Table 2-3 indicate that production instability for the period 1966-1979 was nearly double that experienced over the 1949-1962 period. The move towards greater concentration and specialisation, caused by the declining availability of dairy by-products, has not been accompanied by greater production stability.

The usual explanation for production instability in the pig industry is that a large number of low cost producers with small herds can and do respond quickly to the fluctuating profitability of pig production. The fact that these producers control only a small proportion of the national herd is presumed to be offset by the effect on production stability of a large number of these producers entering and leaving the industry. Assuming that all herds of under 100 pigs are in the "small, low cost" category,¹¹ then it is possible for these herds to be responsible for a considerable proportion of total production instability. The average deviation of total production from trend is approximately 5 percent and herds of less than 100 pigs comprise approximately 15 percent of the national herd. Tables 3-1 and 3-2 present what little evidence is available on the source of production instability by farm size. These tables indicate that, although the fluctuations in each herd size group are roughly similar, not all groups fluctuate in the same direction at the same time. The outstanding feature of Table 3-1 is the continued expansion of the 1000+ group throughout the period.

11. A full time one man unit is assumed to carry approximately 350 pigs on average. This is based on a farmer producing bacon weight pigs and buying in compounded feed (see Pork Industry Council, Pig Production and Management Manual, p.11 (Production)).

Table 3-1

Variation in Number of Pigs by Herd Size
1973-1978 (percentage change)

<u>June Year</u>	<u>Herd Size Group</u>				
	<u>1-19</u>	<u>20-99</u>	<u>100-499</u>	<u>500-999</u>	<u>1,000+</u>
1978	-13.1	-16.7	-9.1	-6.2	15.5
1977	6.0	7.1	0.8	28.3	19.6
1976	2.1	1.3	5.4	11.3	8.0
1975	-0.4	-13.7	-10.4	-17.0	3.2
1974	11.7	- 8.7	- 7.2	- 0.4	2.5
1973	-7.7	-15.7	- 4.1	10.2	13.1
Average Absolute Change	6.8	10.5	6.1	12.2	10.3

Table 3-2

Proportion of Change in National Herd Attributable to
Size Group 1973-1978 (change in herd size group as a
percent of change in national herd)

<u>June Year</u>	<u>Herd Size Group</u>					<u>Total</u>
	<u>1-19</u>	<u>20-99</u>	<u>100-499</u>	<u>500-999</u>	<u>1,000+</u>	
1978	31.3	104.5	148.9	60.5	-245.3	100
1977	2.5	7.7	2.5	39.5	47.8	100
1976	4.2	7.8	7.9	70.7	9.6	100
1975	0.2	22.5	44.3	34.0	- 1.0	100
1974	-15.9	43.7	91.9	2.2	- 21.9	100
1973	140.3	1,150.3	685.2	-638.2	-1,238.1	100
Average	27.1	222.7	163.4	- 71.9	-241.5	100

Source: Department of Statistics, Agricultural Statistics,
1971/1972-1977/78.

This has resulted in the largest producers in the industry having a stabilising influence on production (i.e. greater specialisation and concentration has had a stabilising influence). However, the figures in Table 3-2 also disprove the popular belief that it is the very small producers that cause most of the production instability in the industry. Although variation in the 1-19 herd size group has tended to increase the variation in the national herd, the contribution of this small group to total variation is small. In fact it is the 2-499 herd size groups (the larger part-time and smaller full-time farmers) that provide most of the destabilising influence (the "average" figures for both the 20-99 and 100-499 groups at the bottom of Table 3-2 are both large and positive). However, too much should not be deduced from data which covers such a limited period.

The move to grain feeding of pigs has had two completely different types of effects on the instability of production. On one hand, expansion of the 1,000+ herds has tended to stabilise production. Increased specialisation has also resulted in higher and more consistent productivity performance which exerts a stabilising influence on farm profitability. However, these stabilising influences have been more than off-set by the destabilising effects of the move to grain feeding (especially on the middle sized pig farm). As noted in Chapter Two, the move to the grain ration feeding of pigs has resulted in the pig-meat market being subjected to larger exogenous shocks (especially from the instability of feed costs) at the same time as the market is likely to have become increasingly sensitive to these domestically produced shocks.

The cost of dairy by-product was both very low and very stable, especially for those producers with skim-milk available on-farm. However, the cost of grain rations has been subject to marked fluctuations throughout the 1970's and, because the cost of these rations is approximately equal to

70 percent of the total cost of producing a grain fed pig,¹² the profitability of production is very sensitive to fluctuations in feed costs.

Instability in feed costs is the result of fluctuations in the cost of protein supplements (which make up about 15 percent of a mixed meal diet by weight)¹³ as well as changes in the cost of cereals. The cost of the major protein supplements (meat meals) is very unstable. For example, over a 6 month period (February 1976 to October 1976) a 100 percent increase in meat and bone and blood meal was recorded.¹⁴ Large fluctuations in the costs of protein supplements are a result of changes in New Zealand exports of feed protein and the residual nature of the protein market facing many producers. In 1975/76 (the latest year for which official estimates are available), meat export works, abattoirs, and rural slaughter houses, sold 82,855 tonnes of meat meal, bone flour and meat and bone meal 24,179 tonnes (or 30 percent) was exported and 38,563 tonnes (or 48 percent) was purchased by firms primarily engaged in the manufacture of animal foodstuffs.¹⁵ This leaves a little over 20 percent of the meat meals sold consumed by farmers who mix their own rations, and others. This relatively small residual share of the market combined with an unstable export demand for protein supplements means that the pig farmer mixing his own rations faces extremely unstable

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12. Pork Industry Council, Pig Production and Management Manual
 13. I. J. Shearer, "The Feed Grain Crisis", Pork Industry Gazette, June 1974, p.42
 14. D. Dobson, "BMP Scheme Report", Pork Industry Gazette, April 1979, p.51.
 15. Department of Statistics, Census of Manufacturing 1975/76, Manufacturing Series C No.4 - Food Industries Other, April 1979 "for Industry No.31220 "Prepared Animal Feeds", and Manufacturing Series C No.2 - Food Industries - Meat, Slaughtering, Preparing and Processing, April 1979 (For Industry 31111 - Meat Export Works; including Export Licensed Abattoirs and Industry 31112 Other Abattoirs and Rural Slaughter Houses). The Export figures are taken from the Department of Statistics, Exports.

meat meal prices. The export demand for meat meals fluctuates quite markedly. In the June 1977 year, export volumes were 15 percent higher than the previous year and the price facing pig producers increased from \$210/tonne in August 1976, to \$280/tonne by June 1977 (i.e. 33 percent).

A similar situation exists in the feed-grain market. King has estimated that, in the 1970 year, only 35 percent of the barley and 12 percent of the maize fed to livestock was consumed by pigs. (Poultry production consumed about 50 percent and 70 percent respectively).¹⁶ Although the grain consumption of the national pig herd has increased considerably since 1970 so has both feed-grain and poultry production. The most recent census of manufacturing indicate that by 1975/76 only 13 percent of all compound feeds produced were fed to pigs (versus 73 percent fed to poultry).¹⁷ Although pigs are likely to consume more than 13 percent of the grain consumed by all livestock (because of the relatively low proportion of pigs fed prepared compound feeds - See Table 2-2) they are unlikely to consume more than a quarter of this grain. Contractual arrangements between feed-grain producers and other feed-grain users aggravates the residual nature of the feed-grain market facing many pig producers. As many pig producers with large herds also forward contract their grain supplies this residual market instability can be particularly serious for owners of medium sized pig herds who mix their own rations. Feed-grain prices have varied considerably. For example, the 1974 seasons prices for feed-grains were approximately 50 percent higher than 1973 seasons prices. These price increases were associated with only a 12 percent reduction in barley and maize production.

Although instability in feed-grain and feed-protein prices are likely to have been the single most important cause of

16. J. M. King, Grain Consumption in New Zealand, p.39 and p.45. These figures only include feed-grain passing through the commercial sector (and even then only 87 percent of the firms responded to the 1977 MAF survey used by King).

17. Department of Statistics, Manufacturing Series C, No.4 - Other Food Industries.

the increased production instability associated with the transition to grain feeding, other factors could also have been important. Chapter Two discussed the possibility that the increase in prices for pig-meat could have removed the stabilising influence of export prices on the domestic market. This could have made the market more vulnerable to domestically produced exogenous shocks at a time when the instability in feed-grain costs was particularly important. The trend towards the predominance of specialist pig producers could have also increased the sensitivity of output to changes in the profitability of production (which would exaggerate the "inherent" instability in the market). When pig production was closely associated with dairy production on the same farm it would have been far easier for farmers to maintain pig production levels in the face of a decline in the profitability of the pig enterprise. In the dairy pig production regime it would have been more difficult to identify changes in profitability of the pig enterprise (as a separate production activity) and even if these changes were identified, the dairy-pig farmer had the option of financing his pig enterprise (through what he may have perceived as a temporary slump in profitability) from within the farm. On the other hand, the specialist pig producer is acutely aware of the profitability of the pig enterprise and, in most cases, must rely on external borrowing to finance his operation through temporary slumps in profitability.

All of these factors are likely to weigh most heavily on the middle-sized pig farm. Large farmers are more likely to try and protect themselves against fluctuations in profitability by some contractual arrangements for the purchase of feed-grain and the sale of stock. In some cases very large herds are owned by meat processors and wholesalers who are able to maintain pig production through prolonged downturns because of the complementarity between their pig enterprise and their processing and wholesaling

operations. It may also be considerably easier for the large herd owner to finance his way through cyclical downturns in profitability. At the other extreme, the owner of a small pig herd is also able to finance his pig operation through temporary downturns in profitability (because pig production is not his primary source of income), and may not be forced to rely on either the grain ration or normal pig-meat markets to buy all his inputs or sell all his output. It is also quite likely that the small, non-specialist producer is less aware of the profitability status of his pig enterprise at any particular time. In contrast, the owner of a middle-sized pig herd is likely to be fully exposed to fluctuations in both input and output markets and less able to protect himself from these fluctuations.

3.3.3 Causes of Instability - Conclusion

Although the New Zealand pig-meat market exhibits many of the characteristics of a perfectly competitive market, the presence of economic friction and imperfect knowledge is sufficient to cause the underlying market dynamics to be unstable. This "inherent" instability has been coupled with exogenous shocks which have been exaggerated by the increasing predominance of grain based ration feeding of pigs. Production instability for the 1966-79 period was really double that over the 1949-62 period. The move to the grain feeding of pigs has resulted in the market being subjected to larger exogenous shocks (primarily a result of the increased instability of feed costs). The natural instability in the market for animal feeds is exaggerated because of the residual nature of the market facing pig producers.

Although instability in feed costs are likely to have been the single most important cause of the increase in production instability in the 1970s, other factors associated with the

transition to grain feeding could also have been important. In particular the increase in pig-meat prices (which may have resulted in the loss of the stabilising influence of export prices) and the increased specialisation in production (which may have made the supply curve more elastic) could have been important

3.4 The Consequences of Instability

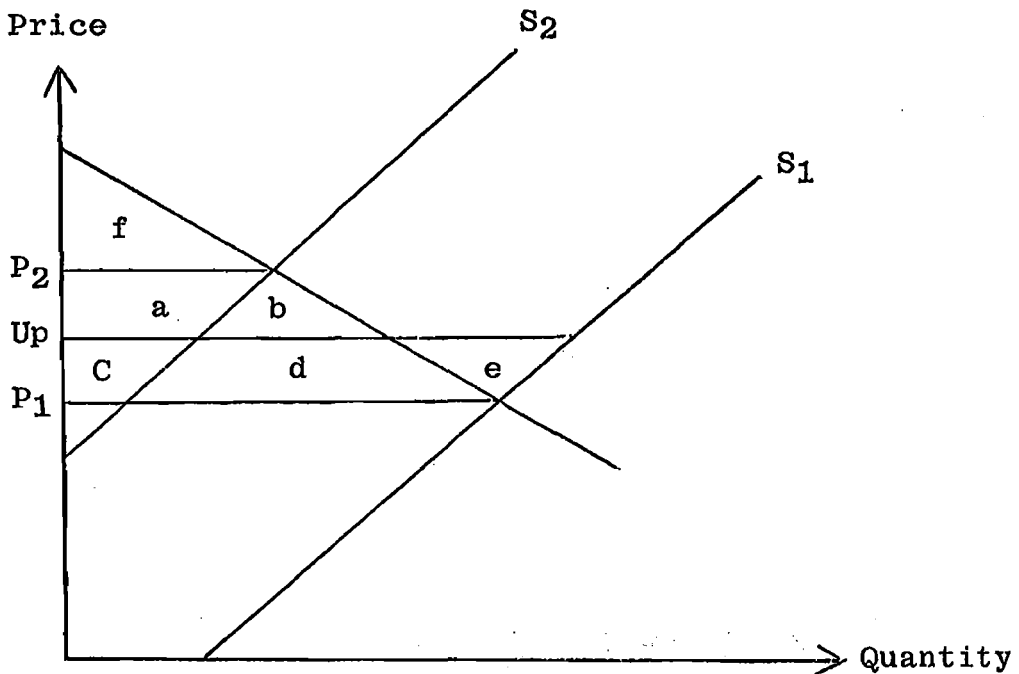
To make a case for some form of action to stabilise the pigmeat market it is first necessary to demonstrate that instability results in welfare loss.

Waugh¹⁸ has demonstrated that consumers may benefit from price instability generated by fluctuating shifts in supply while Oi¹⁹ has shown that producers may benefit from price instability resulting from fluctuating shifts in the demand curve. However, both Waugh and Oi considered consumers and producers separately without integrating both sides of the picture. More recently, Massell²⁰ used a model with both producers and consumers to argue that, no matter whether instability is caused by shifts in supply or demand, the actual payment of compensation would mean that both producers and consumers would prefer price stability.

The Massell analysis, with a shifting supply curve, is shown in Figure 3-2.

An important assumption in both Waugh's and Oi's work is that consumers (producers) are faced with either of two competitively determined prices (P_1 or P_2) and that each price occurs with

18. F. V. Waugh, "Does the Consumer Benefit from Price Instability?", Quarterly Journal of Economics, LVIII, August 1944, p.602-14
 , "Consumer Aspects of Price Instability", Econometrica.
Volume 34, April 1966, pp 504-8.
19. Walter Oi, "The Desirability of Price Instability Under Perfect Competition", Econometrica, Volume 29, January 1961, pp 58-64.
20. F. Massell, "Price Stabilisation and Welfare", Quarterly Journal of Economics, Volume LXXXIII, May 1969, pp 284-298.

Figure 3-2Effects of Price Stabilisation with
a Shifting Supply Curve

a 0.5 probability. Massell assumed that the stabilised price ($Up = \frac{1}{2} (P_1 + P_2)$) could be achieved through a costless storage activity. If the price is increased from P_1 to Up producers gain $(c + d + e)$ and consumers lose $(c + d)$ resulting in a net gain equal to area e . Similarly reducing the price from P_2 to Up results in a net gain of b . Therefore, stabilising the price at Up leads to a net loss to consumers $((c + d) - (a + b))$ which is the Waugh result, but a net gain to consumers and producers combined $(b + e)$, which is the Massell result. Thus producers are able to compensate consumers so as to leave both groups better off from price stability. If price fluctuations are caused by shifts in demand, producers will lose from price stabilisation (the Oi result) but consumers will be able to compensate producers so as to leave both groups better off from price stability.

The analysis of Waugh, Oi and Massell has been usefully extended by Turnovsky²¹ who considered the case where supply decisions must be made before the actual price is known so that these decisions must be based on some kind of price expectations (the underlying assumption of all cobweb type analyses). He concluded that:

"Massell's results that stabilisation provides a net gain to producers and consumers taken together continues to hold in both cases (i.e. with both "adaptive" and "rational" price expectations hypotheses). In fact one can derive the intuitively expected result that the gains from price stability are higher when supply is based on expected prices (again in both cases) than when it depends upon actual prices (perfect information)".²²

The Waugh, Oi, Massell, and Turnovsky analyses are all likely to underestimate the costs of instability in the pig-meat market. Firstly, as both Massell and Turnovsky note, the analyses focus on expected profit and therefore assume that firms are risk neutral; "It is intuitively clear that if instead they (firms) are risk averse, the desirability of price stability will be increased."²³ Secondly, if the analysis was extended to a general equilibrium framework it is quite possible that greater stability in the pig-meat market would help to stabilise the demand for feed-grain rations and therefore reduce the severity of this important source of exogenous shock. Thirdly, instability in the pig-meat market is likely to have an adverse affect on productivity which would aggravate the losses caused by instability. In the cobweb type of analysis producers increase capacity beyond equilibrium levels in response to higher than equilibrium prices. If some of this investment

21. S. J. Turnovsky, "Price Expectations and the Welfare Gains from Price Stabilisation", American Journal of Agricultural Economics, Vol. 56, 1974, pp 706-716.

22. Ibid, p.715

23. Ibid, p.715

cannot be transferred into other productive activities then the productivity of these assets will fall. For example, in the case of stock, instability will tend to lower the average working life of the herd below its economic life under stable conditions, and, in the case of specialist pig housing, instability will tend to lower the utilisation of the asset below the utilisation levels achieved under stable conditions. Therefore, in aggregate, instability may lead to an over-allocation of resources to production. There is also a risk that, given imperfect capital markets, instability will result in a transfer of resources away from small, but efficient, producers who are unable to finance themselves through a temporary downturn in profitability, towards large, but less efficient, producers who are able to raise this finance (either from within the farm or externally).

3.5 The Basic Minimum Price Scheme

Chapter Two briefly discussed the establishment of the Pork Marketing Board and associated Price Stabilisation Committee in late 1973. Until 1975 the price setting function of the Board was related to the operation of a basic fob price for pig-meats. However, on the basis of a recommendation of the Committee of Investigation into Pig Trading and Marketing,²⁴ the Basic Minimum Price Stabilisation Scheme was established in 1975 and a Committee formed to recommend a BMP for all pigs.

"Under this scheme the Board would purchase pigs surplus to New Zealand requirements and pay a price which would enable efficient farmers to remain in an economically viable situation. It was also envisaged that the majority of pigs so purchased would be removed from the local market to export. Associated

24. Report of the Committee of Investigation into Pig Trading and Marketing, March 1975.

with this scheme was the requirement that the Board operate a New Zealand market promotion scheme."²⁵

Monies used to finance the purchase of surplus pigs came from a specific levy levied on each pig slaughtered. Essentially the Board sets a floor price (based on a measure of an efficient farmers level of profitability) and stands ready to support this floor by purchasing pigs in the market. To date, the scheme has operated for one period of 18 months, from April 1977 to October 1978 and, in slightly modified form, for a brief period in 1980.

Since its initial period of operation there have been serious doubts about the value of the BMP scheme. There is some evidence (described in detail in Chapter Seven) that, when the 18 month period over which the scheme operated is taken as a whole, the scheme had no significant influence on most farm prices for pigs and acted to depress some farm prices below what they would otherwise have been.²⁶ However, this lack of success has been primarily a consequence of the way in which the scheme was operated. There is no doubt that the design of the scheme could be improved; the way funds are raised could be used to stabilise prices (even a simple change from a specific to ad valorem levy would help in this regard) rather than having (theoretically) a neutral effect.²⁷ There is also no doubt that a better strategy could be devised to meet the industry's stabilisation objectives.

25. Pork Marketing Board, "BMP Scheme Report", Pork Industry Gazette, April 1979, p.49.

26. Basically the scheme acted as a Basic Maximum Price as well as a Basic Minimum Price.

27. In practice the levy has had a destabilising effect on prices because it was reduced (from 30c to 10c per pig) before the 1977/78 price fall and increased (from 20c to \$1.00 per pig) after the stabilisation fund had been exhausted and farm prices were at their lowest level.

3.6 Use of the Model to Improve Stabilisation Policy

The development of an econometric model of the pig-meat market and its adoption as a forecasting and policy evaluation tool should be (and has now been accepted as) an essential feature in the Board's stabilisation strategy. The benefits from applying this type of model should eventually occur at two specific levels; improving the efficiency of the market and improving the efficiency of Board intervention in the market.

3.6.1 Use of the Model to Improve the Efficiency of the Market

We have already noted how both economic friction and imperfect knowledge combine to produce instability in the pig-meat market. Because of the nature of the economic friction in this market (i.e. a biologically determined production lag) there is nothing that can be done to moderate its effects on market stability. However, it is possible to moderate market instability by improving the information available to producers. As long as the model forecasts provide a better guide to producers about future price levels than some combination of past and present prices, then these forecasts will help to stabilise the market. If it were possible to predict future price levels with complete accuracy, and if producers used these predictions as a basis for their production plans, then the inherent instability in the market would be completely removed and any remaining instability in the pig-meat market would be a result of exogenous shocks (i.e. of instability in other markets in the economy or of instability in foreign prices).

There is a problem inherent in this use of model forecasts as a policy instrument. If the model forecasts of future prices are used by producers then an important change in the structure of the market being modelled will have occurred. Because of this change the model's forecast (based on a more naive hypothesis about farmers' price expectations behaviour)

will become less accurate. However, this problem may not be particularly important in practice. It is highly unlikely that all farmers will place complete confidence in the model's price forecasts. If the influence on the model is gradual enough then the structural change it induces may be able to be incorporated into future model re-estimations.

3.6.2 Use of the Model to Improve the Efficiency of Board Intervention in the Market

The model can be used to help the Board make more accurate and better timed policy responses to actual or impending changes in the market and to evaluate the impact of alternative policy responses. Further improvements to the model would enable it to assist the Board in evaluating alternative stabilisation strategies as well as specific policy measures.

In the Board's own evaluation of the operation of the BMP scheme over the 1977/78 period it noted:

"As satisfactory information about future production levels was not available it was difficult for the Board to make decisions regarding the operation of the scheme. This made negotiations with the Treasury difficult and (because the Board was by this stage short of funds) produced a hand to mouth situation which limited the Board's flexibility. Meat had to be sold as quickly as possible on the local market to allow money to be made available to purchase pigs and keep the bank account within the limits laid down."²⁸

The Board was committed in principle to maintaining a basic minimum price to producers that "would enable efficient farmers to remain in an economically viable situation".²⁹ Because the Board did not have a reasonable estimate of the breadth or depth of their likely involvement in the market they were unable to maintain this objective or to continue to keep meat off the local market.

28. Ibid, p.50

29. Ibid, p.49

"During the last nine to twelve months of the scheme's operation the adjustment of the Basic Minimum Price Scheme was finely balanced between depressing production and maintaining an economic price to the efficient producers. Another important factor was the need to balance the bank account of the scheme Because of its relatively small fund the Board decided that the only way to maintain its liquidity was to sell on the local market so that it could continue to purchase pigs."³⁰

Lack of information about future production levels meant that the Board could not inform Treasury (or adequately prepare itself by building up a satisfactory fund for stabilisation) about the probable breadth or depth or their involvement in the market. This resulted in a lack of funds to successfully operate the scheme and severely limited the Board's ability to stabilise the market. As funds became scarce the Board was forced to lower the BMP (by 8 percent in the major market) and increase the levy (from 30 cents per head to \$1 per head). Lack of funds also limited the Board's ability to take stock off the local market at a time of over-supply (by either storage or export) in order to support the local price. However, the cost of maintaining an inadequate stabilisation fund must be weighed against the costs of maintaining an excessive fund. Decisions about the level and management of the stabilisation fund would be greatly assisted by information that could be supplied by the model (e.g. forecasts of supply, demand and price movements and evaluations of the consequences for the stabilisation account of setting BMPs at alternative levels).

3.6.3 Use of the Model to Improve Stabilisation Policy - Summary

The development and application of the type of model described in this thesis has an important part to play in the future of stabilisation policy in the New Zealand pig-meat market. It

30. Ibid, p.52

has the potential, by improving the information available to producers, to modify the inherent instability caused by the lack of perfect information. This approach to stabilisation involves no "intervention" in the market and therefore minimises the possibility that stabilisation policies will introduce new distortions into the market. It is also relatively cheap. Whether or not an acceptable level of stability will be achieved by the policy in practice depends on a number of factors including the accuracy of the forecasts supplied, the magnitude of the exogenous shocks imposed on the market and the influence of changes in the structure of the industry on market stability (e.g. the increasing importance of larger farms - which tend to have a stabilising effect on supply - and the influence of the expanding import trade on price stability).

Whatever the future impact of an improvement in the quality of information available to producers, there is likely to be a continued demand for interventionist stabilisation policies at least over the next few years. Whether or not these policies will increase net economic welfare will depend on how they are operated as well as how they are designed. Both pig producers and the industry organisation are aware that both the design and operation of their present stabilisation strategy could be improved. There has been some speculation that the "cures" for instability used to date may have in fact been worse than the original "disease".

What has become clear is that the industry needs more and better quality information if it is to improve both the design and operation of its stabilisation strategy. The development of the econometric model described in this thesis is the first major step taken in an attempt to provide the information required.

3.7 Conclusion

Market instability is widely accepted as the major problem facing the New Zealand pig industry. It is a problem over which the industry organisation can exercise some control. This chapter discussed the causes, consequences and current "cures" for this instability as well as the part that an econometric model of the market can play in improving stabilisation policy.

Instability is caused by factors "inherent" in the market structure as well as by exogenous shocks. The move towards grain feeding of pigs has aggravated production instability throughout the 1970s. The discussion of the consequences of this instability concluded that instability results in a welfare loss as well as having an adverse effect on productivity in the industry.

The present industry response to production instability was also discussed. It was concluded that both the design and operation of the BMP scheme could be improved. Finally, the part that an econometric model of the market could play in improving stabilisation policy was discussed. This type of model has the potential to improve the efficiency of the market. The development of the model outlined in Chapter Four and developed in detail in Chapters Five to Nine is the response adopted in this thesis to the problem of instability in the New Zealand pig industry. The rest of this study is concerned with developing and evaluating an econometric model of the market as a policy tool which can be used by the industry organisation to improve its stabilisation policy.

CHAPTER FOUR

AN OVERVIEW OF THE COMPLETE MODEL; STRUCTURE AND ESTIMATION

4.1 Introduction

This chapter discusses a number of important issues associated with the specification and estimation of the complete model developed in this study. The first section discusses the basic model structure in detail. Alternative models of the pig-meat market are discussed along with the appropriate level of market and regional aggregation and the major relationships between the endogenous variables in the model. Of particular interest is the process of price formation in the model. The second section discusses whether or not these relationships between the endogenous variables are simultaneous or recursive. Having identified the lines of causality in the model, the final section in the Chapter discusses the choice of an appropriate estimation technique, estimation period and data periodicity. A number of criteria are applied to the estimation techniques available to select the technique most appropriate to estimate the model described. This choice is affected by the lines of causality in the model, the identification condition of the model and the availability of data as well as the characteristics of the individual estimation techniques.

4.2 Basic Model Structure

This section discusses the major issues which determine the basic model structure. It is intended as a brief description of the model as a whole and is a useful introduction to the detailed discussion of individual equations presented in Chapters Five to Nine. Initially, the model structure used by Yandle is discussed and the reasons for rejecting that

structure for this study are advanced. Secondly, the need to distinguish the fresh pork and cured product "markets" is discussed. Thirdly, the basic model structure is developed from the simple cobweb model through the more complex Meadows' model to a structure that adequately represents the complexities in the New Zealand Pig-meat market. Finally, the basic equation structure of the model is presented.

4.2.1 Yandle's Model Structure

Yandle implicitly accepted a simple cobweb model of the New Zealand pig-meat market in his 1968 study by assuming that the quantity of both pork and "bacon and ham" consumed in any one quarter was predetermined (i.e. that supply was predetermined and that supply and demand were identical).¹ In Yandle's model, with consumption predetermined, the retail price is a function of the quantity demanded rather than vice versa. Yandle was unhappy about this assumption for the "bacon and ham" market but was required to retain it because of data limitations:

"The assumption which was used was that demand equalled supply. This can be considered an unsatisfactory, though necessary, approximation to a market situation where processors of baconer pigs marginally adjust seasonal supply through stock changes to maximise annual profit."²

However, in the pork market, Yandle maintained that demand was predetermined because the variables whose current values were thought to affect current supply were unlikely to have changed supply by more than "marginal amounts" and, because quantities of pork exports were small and stocks non-existent, pork demand equalled pork supply.

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1. C. A. Yandle, op cit, see pages 119-121 for a discussion of pork demand and pages 124-127 for a discussion of demand for "bacon and ham".
 2. Ibid, p.126.

Although the consumption and production of fresh pork are very similar (albeit exports have exceeded 10 percent of consumption in some quarters), it would be incorrect to maintain that pork production was predetermined. The pork market is both smaller and considerably more volatile than the "bacon and ham" market. It is supplied by a large number of predominantly baconer producers (to whom pork production is either a residual or speculative activity) as well as a small number of "specialist" porker producers. Both groups are prepared to alter the level of their porker production to changes in the relative profitability of porker and baconer production. There is also good reason to believe that this relative profitability has become considerably more volatile since Yandle completed his study because it is now sensitive to changes in feed-grain ration prices as well as the relative farm prices of baconer and porker weight pigs.

Fluctuations in the supply of porker weight pigs are also likely to have been significantly increased by the marked increase in the instability of total production. For example, baconer producers going out of production are likely to slaughter a high proportion of pigs originally destined for bacon production at the light pork weight irrespective of "normal" fluctuations in the profitability of porker with respect to baconer production. Given the changes noted above, Yandle's specification is no longer applicable to the pig-meat market.

4.2.2 Distinguishing the Fresh and Cured Product Markets

Fresh and cured pig-meat are two distinct products produced and marketed by a number of distinct, yet closely related, production and marketing systems. Yandle noted that these two products are not competitors at the retail level.³

However, baconer and porker pigs are close substitutes in production. The only distinction between live pigs destined

3. Ibid, p.122

to be consumed either fresh or cured is their liveweights at slaughter; "porker" pigs (destined for the fresh meat market) have a carcass weight less than 41kg while "baconer" pigs (destined for consumption as bacon and ham) have a carcass weight in excess of 41kg. It is very easy for producers to switch from producing one class of pig to the other in response to changes in the relative profitability of porker and baconer production. In addition, "specialist" producers of bacon weight pigs will produce a number of pork weight pigs as slower growing animals are slaughtered in an effort to increase the utilisation of the available pen space (i.e. porker production is partially a 'residual' of baconer production.)⁴

The baconer and porker weight carcasses are gradually distinguished into non-competitive products by the marketing system. Although economic factors usually preclude curing lightweight pigs, some baconer weight carcasses are consumed as fresh meat. However, once baconer weight carcasses are cured the two types of carcass are no longer substitutable. The two types of meat are also handled by different marketing chains. Porkers are generally cut as fresh meat joints and sold through butchers' shops and supermarkets while baconer pigs are used mostly by major processors for curing into bacon and ham. Bacon is sold through a wider variety of retail outlets (including dairies). It is also important to note that virtually all imports and all stocks of pig-meat are destined for the cured meat trade.

In summary, although fresh and cured products are distinct in the retail meat trade baconer and porker carcasses are

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4. As pigs do not mix well (i.e. mixing pigs from different pens results in fighting, carcass damage and slower growth) slow growing pigs will be slaughtered when most of their pen mates have reached baconer weight. This allows the farmer to put a new group of pigs into the pen. A number of pigs may also be slaughtered at light weights to relieve the pressure of numbers on pen space (i.e. to keep pen utilisation high the farmer may place a large number of young pigs in a pen and slaughter a few (at light weights) to relieve pressure on pen space).

close substitutes in production. These products are gradually distinguished into non-competitive products by the marketing system. Therefore, although these two product "markets" must be clearly distinguished in the model, the interaction between them implies some overall equilibrium in the pig-meat market as a whole.

4.2.3 Development of the Model Structure Used in this Study

Chapter Three discussed the simple cobweb model used by many authors as a representation of pig-meat markets overseas.

That chapter also discussed the extension of the simple cobweb model to include stocks and Meadows' application of this extended model to explain production and price fluctuations in the United States pig-meat market. In the Meadows model prices are determined by stock holders (who alter prices to maintain stock coverage at some desired level) rather than determined by the equality between production and consumption.

The model structure used to represent the New Zealand pig-meat market is a further development of the simple cobweb structure. Firstly, the fresh and cured product "markets" must be clearly distinguished in the model. The importance of stocks in determining farm prices in the cured product market requires that a Meadows type model be used to represent this market. However, the absence of fresh pig-meat stocks indicates that price determination in the fresh pig-meat market would be better represented by a simple equilibrium model. In this case, prices are found by solving the model for equilibrium values of supply and demand.

Secondly, the hypothesized simultaneity between supply and farm price implies an important extension of the simple cobweb structure. For example, the hypothesis that farmers will respond to price increases by retaining more bacon weight pigs

for inclusion into the breeding herd is not compatible with the simple cobweb model in which supply is a function of past prices only.

Thirdly, the New Zealand pig-meat market is considerably more complex than either the simple cobweb or Meadows' model representations. These models have to be extended to include foreign trade in pig-meat as well as the difference between farm and retail prices. The model developed in this study includes pig-meat imports and exports and separately models price formation at both the farm and retail levels.

Finally, the model also has to be disaggregated geographically if it is to adequately represent the New Zealand pig-meat market. Chapter Two discussed the regional impact that the move to grain based ration feeding had had on pig production. It also compared some selected characteristics of North and South Island pig production and concluded that there were important differences between pig production systems in each island. These differences are important enough to require that production should be disaggregated by island in the model.

These extensions of the simple models discussed in Chapter Three were considered necessary to adequately model the relationships in the New Zealand pig-meat market. They were also considered important by policy-makers who are interested in separately identifying the impact of policy, and other, changes at the level of disaggregation implied by the extensions listed above. However these extensions require that sufficiently disaggregated data is available. Unfortunately, data is not available in a regionally disaggregated form that would allow us to retain a simple equilibrium model of the fresh pork "market". In order to regionally disaggregate the simple equilibrium model each equation would need to be specified and estimated separately for both North and South Islands.

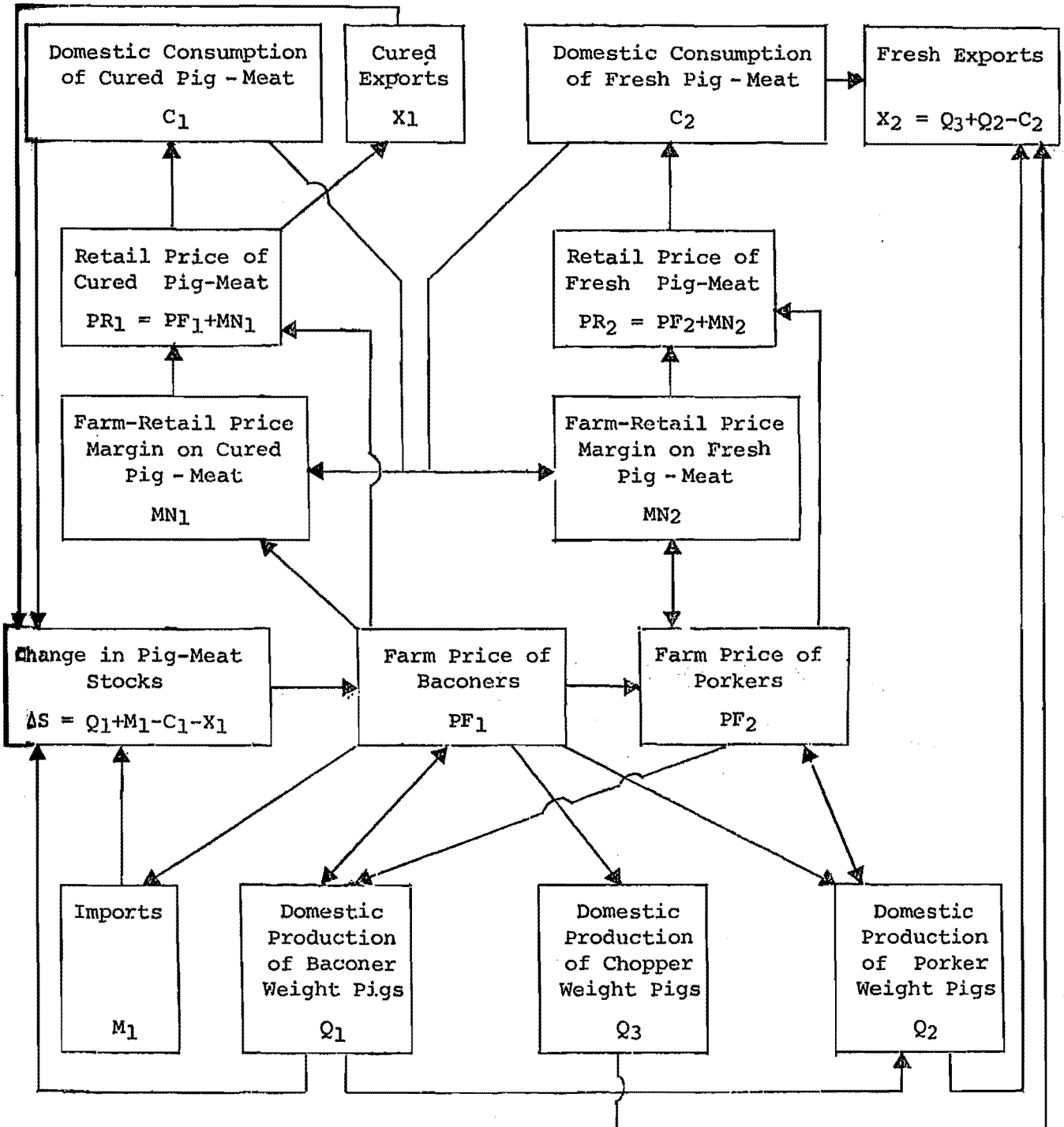
Because of the important differences between pig production in the two islands and the importance that policy-makers attach to distinguishing supply response in each island, it was decided to retain the regional disaggregation in the model and modify the simple equilibrium model representation of the fresh pork "market". Therefore the farm price for porkers in each island was determined explicitly in the structural form of the model (as a function of the supply of porkers and the farm price of baconers) and this part of the model was closed by an identity which determined fresh pork exports as a residual (which is equal to production minus consumption).

This alternative specification of the fresh pork component of the model has one disadvantage; fresh pork exports will tend to be very unstable. For example, it is possible given the relative size of these exports for the model to solve for negative values of fresh pork exports. This problem is reduced by constraining the size of these exports. The lower bound for these exports has been set at zero and the upper bound set at the largest single quarterly change in exports experienced over the estimation period. These restrictions ensure that the solution value of fresh pork exports found by the model will lie within limits which are considered realistic on a priori grounds.

A simplified schematic representation of the New Zealand pig-meat model is presented in Figure 4-1. This diagram shows the major links between the endogenous variables. However the arrows used in the diagram do not imply one way causal links in the model. These endogenous variables are, as we will discuss in the next section, determined simultaneously.

Figure 4-1

A Simplified Schematic Representation of the New
Zealand Pig-Meat Model



Note: This is a highly schematic representation of the relationship between the endogenous variables in the model. Only the most important directional relationships are indicated and no lags are shown. Neither is the regional disaggregation of these variables identified. The four identities in the model (i.e. X_2 , PR_1 , PR_2 and ΔS) are shown; values for all the other variables are found using behavioural equations.

The domestic production and farm price equations are regionally disaggregated in the actual model although all of the other variables appear as national aggregates. This diagram clearly shows the close association between porker and baconer production compared with fresh and cured product consumption. Interaction between the two markets is also important in determining farm prices (although the relative importance of the baconer market dominates this relationship). Also illustrated is the hypothesized importance of stocks in determining farm prices for baconer pigs.

4.2.4 Basic Equation Structure

The basic equation structure of the model illustrated in Figure 4-1 is described in Figure 4-2. Figure 4-2 describes the model in greater detail than Figure 4-1. The geographical disaggregation is described as well as the way in which the regionally disaggregated production and farm price components of the model are combined with the aggregated margin, retail price and consumption components. This description also allows for a complete description of the four identities in the model. However, the relationships illustrated in Figure 4-2 are indicative only and the actual estimating forms of the behavioural equations in the model are described in detail in Chapters Five to Nine. The model has 20 equations, 16 behavioural equations and four identities. Two additional equations are used to simplify the model when it is used for simulation or prediction. These two additional equations are used to aggregate the regional farm prices (i.e. $PF_1 = \sum_{j=1}^2 W PF_{ij}$).

Figure 4-2Basic Equation Structure of the
New Zealand Pig-Meat Model

<u>Equation Group</u>	<u>Equation Number</u>	
Consumption	(1- 2)	$C_i = f^1(PR_i, Z, U_1) \quad i=1,2$
Margin	(3- 4)	$MN_i = f^2\left(\sum_{j=1}^2 WPF_{ij}, TPUT, Z, U_2\right) \quad i=1,2$
<u>Farm Price:</u>		
Baconers	(5- 6)	$PF_{1j} = f^3(Q_{1j}, AS, Z, U_3) \quad j=1,2$
Porkers	(7- 8)	$PF_{2j} = f^4(Q_{2j}, PF_{1j}, Z, U_4) \quad j=1,2$
<u>Production:</u>		
Baconers	(9-10)	$Q_{1j} = f^5(PF_{1j}, PF_{1jt-k}, PF_{2jt-m}, Z, U_5) \quad j=1,2$
Porkers	(11-12)	$Q_{2j} = f^6(PF_{2j}, PF_{1j}, Q_{1j}, PF_{2j-t-p}, Z, U_6) \quad j=1,2$
Choppers	(13-14)	$Q_{3j} = f^7(PF_{1j}, Z, U_7) \quad j=1,2$
Bacon Exports	(15)	$X_1^* = f^8(PR_{1t-1}, Z, U_8)$
Bacon Imports	(16)	$M_1^* = f^9(PF_{1t-1}, Z, U_9)$
Retail Price	(17-18)	$PR_i = \sum_{j=1}^2 WPF_{ij} + MN_i \quad i=1,2$
Stock Change	(19)	$AS = \sum_{j=1}^2 Q_{1j} + M_1 - C_1 - X_1$
Pork Exports	(20)	$X_2 = \sum_{j=1}^2 \sum_{i=2}^3 Q_{ij} - C_2$
<u>Restrictions:</u> $M_1 > 0$		

* Predetermined

where:

- i = 1 (bacon), $i=2$ (pork), $i=3$ (chopper⁵)
 j = 1 (North Island), $j=2$ (South Island)
 C_i = Consumption of good i
 MN_i = Farm - Retail price margin on good i
 PF_{ij} = Farm Price of good i in region j
 Q_{ij} = Domestic Production of good i in region j
 X_i = Export of good i
 M_i = Import of good i (where i only equals one)
 PR_i = Retail Price of good i
 ΔS = Change in stocks of cured product
 $\sum_{j=1}^2 WPF_{ij}$ = the weighted farm price of good i for both islands,
 (where: $W = Q_{ij} / \sum_{j=1}^2 Q_{ij}$)
 $TPUT$ = total throughput of all meat at the retail level
 (i.e. includes: $\sum_{i=1}^2 C_i$)
 k = lag between price and output changes of bacon weight pigs
 m = lag between price changes for porker weight pigs and changes in the production of bacon weight pigs
 p = lag between price and output changes of pork weight pigs

5. Choppers are a manufacturing grade of slaughter pig (which are used almost entirely for sausages, pies and other convenience foods) and include all sows and boars.

4.3 Causality

The relationship between endogenous variables within a model can be either recursive, implying causal dependence over time, or simultaneous, indicating interdependence within a single period. Determining causality among the endogenous variables is essential to the correct specification of the model and affects the choice of estimation technique. The simple cobweb model described in Chapter Three is a good example of a recursive model; the endogenous variables in the model are determined sequentially.

Two factors are important in determining causality in the model; the basic structure of the model and the length of the data interval related to the time lag existing between variables. Tomek and Robinson⁶ note four conditions under which a simultaneous specification may be preferred to a recursive specification. First, where the number of animals available for slaughter is predetermined, the number actually slaughtered may still be simultaneously determined with current price. Second, when the lag in the production process is short relative to the data interval. Third, if current production does not equal current consumption (e.g. because of stock changes, imports, or exports) current price and total supply may be simultaneously determined even when production is predetermined. Finally, the need for simultaneity arises when the allocation of total production among alternative uses is not predetermined (even though total production may be predetermined).

The model illustrated in Figure 4-2 exhibits three of these four conditions. Simultaneity exists in the model despite the fact that the time lag in pig production is greater than the time unit of observation (implying that the level of productive capacity is predetermined). The total quantity

6. W. G. Tomek and K. L. Robinson, "Agricultural Price Analysis and Outlook", in L. R. Martin (ed) A Survey of Agricultural Economics Literature, Volume 1 : Traditional Fields of Agricultural Economics 1940's to 1970's, University of Minnesota Press, 1971, p.333.

of pig-meat supplied from farms is simultaneously determined with current price because of the influence that changes in breeding herd numbers have on slaughter rates. For example, if the farm price increases farmers will respond by increasing breeding herd numbers hence saving a larger number of slaughter weight pigs as potential breeding stock. The consumption of pig-meat is also simultaneously determined with current price because pig-meat consumption is a component of traders total meat throughput which is assumed to be inversely related to traders margins. Secondly, current production need not equal current consumption because of changes in inventory levels and the influence of imports and exports. Both exports of pork weight pigs and changes in the level of stocks are determined simultaneously with the other endogenous variables in the model. Finally, the realised level of total production is allocated between the pork and bacon markets depending, in part, on the relative profitability of pork weight versus bacon weight pig production in the current period.

Causality in the model can be verified by examining the matrix of endogenous coefficients. If this matrix is not triangular (i.e. if it has entries above and below the major diagonal) the triangularity test for recursiveness fails and the model is simultaneous.⁷ Table 4-1 shows the matrix of endogenous coefficients and, because this matrix is not triangular, confirms that the model is simultaneous.

The representation of the New Zealand pig-meat market as a closed system implicitly assumes that the market is either sufficiently small or sufficiently isolated to ignore its effect on other markets within the economy. In most cases this is an acceptable assumption however there may well be some causal link from pig production to the feedgrain sector (as well as vice versa). Chapter Three noted that pig

7. A. Koutsoyiannis, Theory of Econometrics; Second Edition, MacMillan Press, 1977, pp 341-342

Table 4-1

Matrix of Endogenous Coefficients for the 22 Equation Version⁸
of the New Zealand Pig-Meat Model

Equ. No.	Endogenous Variable	Q32	X1	M1	PF11	Q11	PF12	Q12	PF21	Q21	Q22	PF22	Q31	PF2	PF1	PR2	C2	PR1	C1	MN2	MN1	ΔS
1	Q32	-1																				
2	X1		-1																			
3	M1			-1																		
4	PF11				-1	X													X			X
5	Q11				X	-1																
6	PF12				X		-1	X														
7	Q12						X	-1														
8	PF21				X				-1	X										X		
9	Q21				X	X			X	-1												
10	Q22						X				-1											
11	PF22						X				X	-1								X		
12	Q31				X								-1									
13	PF2								1	1	1	1		-1								
14	PF1				1	1	1	1							-1							
15	PR2													1		-1				1		
16	C2															X	-1					
17	PR1														1			-1				
18	C1																	X	-1			
19	MN2													X			X		X	-1		
20	MN1														X		X		X		-1	
21	ΔS		1	1		1		1										1	1			-1
22	X2	1								1	1		1				1					

where: X = Coefficient not equal to unity

8. This version has been used for simulation and includes 2 equations used to aggregate the regional farm prices for each commodity (i.e. porker or baconer) into a national price for the commodity using volume weights.

production consumed a significant quantity of the total animal feed produced (although the poultry industry was by far the most important single consumer of animal feed). It would be reasonable to expect that the level of demand for animal feed from within the pig industry would have some influence on the cost of that feed (i.e. that feed costs were endogenous rather than exogenous). This relationship has been ignored in the model in an effort to limit the scope of this study within the resources available. However, it is unlikely that ignoring this relationship has seriously impaired the accuracy, applicability or credibility of the model.

The basic model structure discussed in this section is a development of the simple cobweb model discussed in Chapter Two. The simple recursive cobweb model structure has been developed to a point where it reflects most of the important features of the New Zealand pig-meat market. These developments are necessary if the model estimated from this basic structure is to be useful as a policy tool. Chapters Five to Nine discuss the specification, estimation and evaluation of each of the 16 behavioural equations in the model.

4.4 Choice of Estimation Technique

There are a number of criteria for selecting between the estimation techniques available.⁹ The following criteria have been used in this study: the presence of "simultaneous equation bias", the identification condition of the model, the properties of the parameter estimates, the sensitivity of the technique to errors (both in specification and measurement), the availability of data, and the computational complexity of the technique.

9. For a discussion of various criteria see A. Kontsoyannis, *op cit*, p.498-51; W. C. Labys, Dynamic Commodity Models, 1973, pp 134-147.

The application of ordinary least squares (OLS) to a single equation assumes that there is one-way causation between the dependent variable and explanatory variables. If, as is the case for many of the equations in the pig-meat model, there is simultaneity between the dependent variable and some of the explanatory variables (i.e. some of the explanatory variables are endogenous) then the disturbance term and the explanatory variable(s) will be correlated and ordinary least squares will yield biased and inconsistent estimates.¹⁰ Because of this simultaneous equation bias OLS must be rejected and other methods of estimation which give better estimates of the parameters should be used.

For the identification of the entire model, there has to be at least as many independent equations as endogenous variables and each equation in the model must be identified.¹¹ The identification condition of each equation in the model can be established using the rank and order conditions for identification. The order condition requires that, for an equation to be identified the total number of variables excluded from it but included in other equations must be at least as great as the number of equations in the system less one.¹² The rank condition requires that:

"In a system of G equations any particular equation is identified if and only if it is possible to construct at least one non-zero determinant of order $(G-1)$ from the coefficients of the variables excluded from that particular equation but contained in the other equations of the model."¹³

Once the rank condition is satisfied the order condition can be used to assess the identification condition of the model.

10. For proof see Koutsayiannis, op cit, pp 333-334.

11. Ibid, p.346

12. Ibid, p.352

13. Ibid, p.353

Because the New Zealand pig-meat model is complete and has 91 variables without any single equation having more than 27 variables it is overidentified. With respect to the choice of estimation technique, this means that the indirect least squares method is inappropriate because it does not give unique estimates of the structural parameters.¹⁴

There are still a considerable number of estimation techniques applicable to overidentified simultaneous equation models. They can be classified as being either single equation techniques, which are applied to one equation of the system at a time (e.g. Two Stage Least Squares (2SLS)) or complete systems techniques, which involve the solution of all the equations simultaneously and the estimation of the unknown parameters of all the equations at the same time (i.e. Full Information Maximum Likelihood (FIML) and Three Stage Least Squares (3SLS)). The complete systems techniques involve greater computational complexity and require a larger sample size than the single equation techniques.¹⁵ Although all of these remaining techniques are consistent, the two systems techniques use more information than the single equation methods (i.e. the structure of all the equations of the system and the contemporaneous dependence of the variables of the various equations) and are therefore more efficient than the single equation techniques. However, unless there is contemporaneous correlation between the equation disturbance terms, 3SLS reduces to 2SLS. Although the systems techniques have some advantages;

"these methods (i.e. 3SLS, FIML) are generally more sensitive than the others to specification errors, because an error of specification anywhere in the system affects all the parameter estimates. Given therefore our uncertainty about the correctness of the specification of our model, as well as the errors in variables

14. For a discussion of this point see A. Koutsoyiannis, Theory of Econometrics, p.372.

15. W. C. Labys, op cit, p.137

and the extremely complicated computations of these methods and in particular of FIML, it seems that these methods are less attractive for economic research."¹⁶

Monte Carlo studies have also been used to determine the small sample properties of alternative techniques both with and without specification error.¹⁷ Again, the systems techniques have advantages but are very sensitive to specification error. Both Johnston and Koutsoyiannis favour 2SLS as a practical estimation technique:

"Among the consistent estimation methods it seems that 2SLS may be considered as the best, since it is also the cheapest and simplest to apply."¹⁸

Because of the issues raised above, the 2SLS technique was used to estimate the New Zealand pig-meat model. Apart from its applicability to overidentified simultaneous equation systems and its relative simplicity and robustness, 2SLS could be combined with the method of principal components to enable the model to be estimated with the sample size available.

The 2SLS procedure was followed by applying OLS in two distinct stages. The first stage is used to purge the endogenous explanatory variables of their relationship with the error terms by the OLS regression of the endogenous variables on all of the predetermined variables in the model (i.e. the predetermined variables are used as instruments). These estimated endogenous variables replace the actual endogenous variables as the explanatory variables in the

16. A. Koutsoyiannis, op cit, p.503.

17. For a useful survey see J. Johnston, Econometric Methods, McGraw-Hall, 1963, pp 275-295.

18. A. Koutsoyiannis, op cit, p.509.

model and (because these new variables are purged of their relationship with the error term) each equation can be estimated using OLS.

Unfortunately, the first stage fails where the total number of predetermined variables is greater than the number of observations. The New Zealand pig-meat model has 69 predetermined variables and only 43 observations so either the number of observations had to be increased or the number of "instruments" reduced. The model was estimated using quarterly data with the first observation the fourth quarter 1968 and the last the (then latest available) second quarter 1979. Quarterly data was used because it allowed the maximum number of observations without extending the estimation period into the era when the dairy-pig production regime was predominant. This trade-off between the number of observations and structural homogeneity would have been reduced if more frequent (e.g. monthly) data was available. Although monthly data is available for a number of important series it would have been extremely difficult to obtain monthly data on all the necessary variables without compromising accuracy to an unacceptable degree. Fortunately there were two options available for reducing the number of instruments; the first is to be more selective in the choice of instruments (e.g. Structurally Ordered Instrumental Variables (SOIV)), the second is to use principal components (i.e. use a small number of "components" which account for a large proportion of the total variance in the predetermined variable set to replace the large number of predetermined variables). Laby's notes a number of problems associated with SOIV:

"the method requires that the underlying endogenous variables have some degree of causal dependence, ... the use of extensive a priori information is not an easy matter and the accompanying computational time is substantial ... (and) the reliance on

maximising the regression R^2 (as a selective device) in the end may not reduce consistency by as much as is desirable."19

Because of these problems the principal component method was adopted in conjunction with 2SLS.

Unfortunately, although some criteria are available for selecting the number of principal components to be extracted from the set of predetermined variables, no definite conclusions have been reached as to the number of principal components to include. Kaisers criterion suggests that:

"only principal components having a characteristic root greater than one are considered essential and should be retained in the analysis ... (however) ... when (the number of predetermined variables exceeds 50), this decision rule tends to allow too many (principal components) to remain in the analysis."20

Koutsoyiannis also discusses Cattell's 'Scree Test' criterion which uses a curve plotting the characteristic root against the order of extraction of the components to decide how many components to retain in the analysis:

"The decision rule is to retain the P's (components) up to the point where the resulting curve has some curvature and reject the P's for which the curve becomes a straight line."21

Laby's has a simpler criterion:

"The author's experience suggests that a sufficient number of components should be taken such that the (total) variance accounted for (by the components) is 90 percent."22

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- 19. W. C. Labys, op cit, p.145
 - 20. A. Koutsoyiannis, op cit, p.433
 - 21. Ibid, p.433
 - 22. W. C. Laby's, op cit, p.143

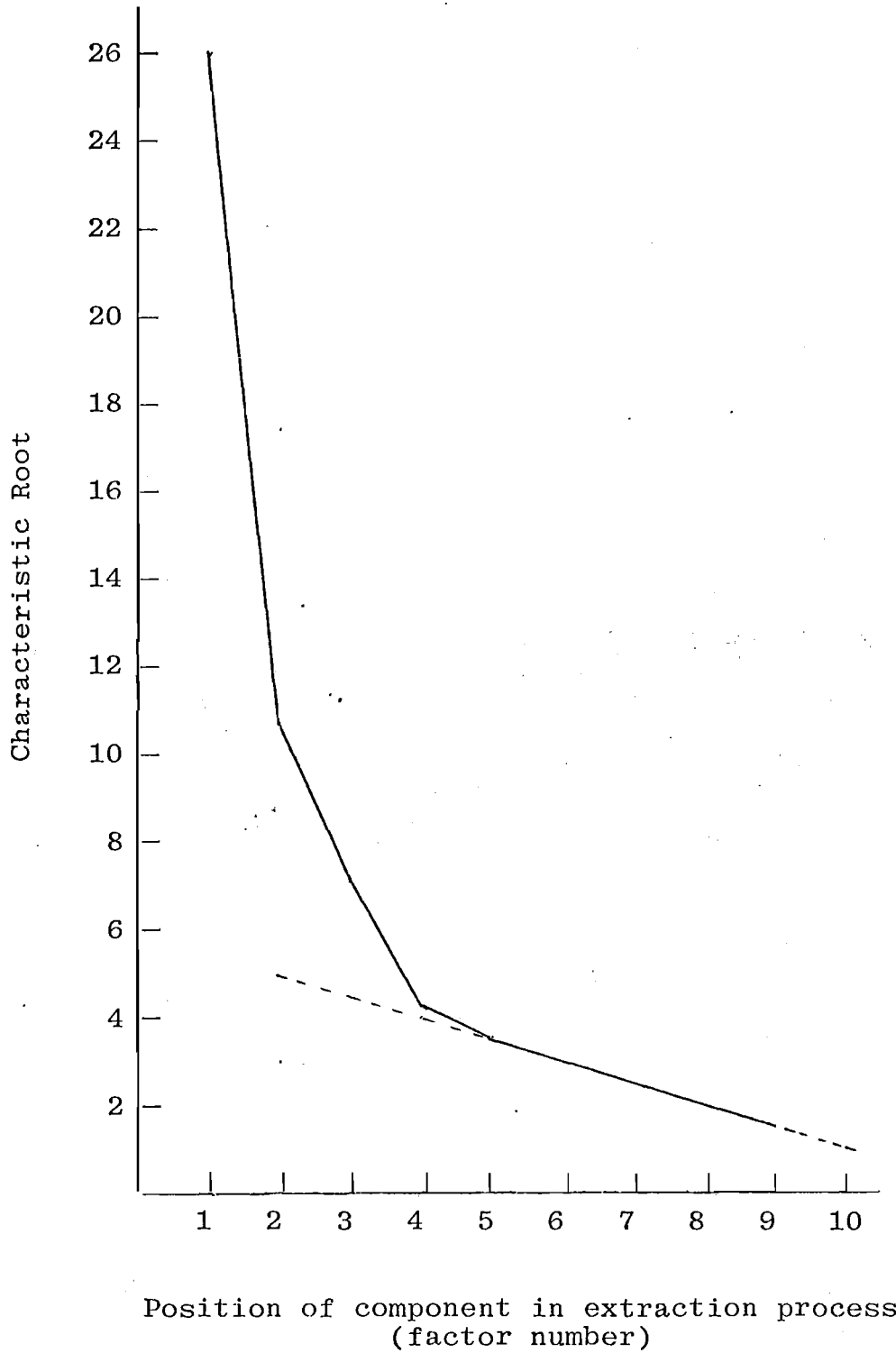
In this study, nine principal components were extracted from the 69 predetermined variables. The relationship between the characteristic root and the order of extraction of the components is illustrated in Figure 4-3. This figure indicates that the relationship between the characteristic root and factor number becomes linear after the fifth component has been extracted. However, the characteristic root of the fifth component is 3.59 (i.e. considerably greater than one) and only 74 percent of the variance is explained by the first five components. All of the nine components have characteristic roots in excess of unity (the ninth component's characteristic root is 1.5) and (in total) account for over 87 percent of the variance in the original variable set. This suggests that all nine components should be retained. Kaisers' criterion would suggest that more components should be taken but; as already noted, because of the number of variables in the predetermined set, this criterion tends to allow too many components to remain in the analysis. Finally, the 87 percent of total variance accounted for by these nine components is sufficiently close enough to Laby's suggested 90 percent to be accepted. Given the uncertainty surrounding the choice of an appropriate number of components, it is comforting that some criteria suggest that less than nine components should be selected while others indicate that more than nine should have been used.

These nine principal components replaced the 69 predetermined variables in the first stage of the 2SLS process (i.e. all of the endogenous variables were "purged" by the OLS regression of these variables on the principal components.²³)

23. Where the endogenous explanatory variable in the model is calculated as a combination of endogenous and predetermined variables (e.g. the change in farm price is an endogenous explanatory variable which is the difference between the endogenous variable 'farm price' and the predetermined variable 'lagged farm price') it is not clear whether the endogenous explanatory variable should be purged or merely its endogenous component. For example, in the case of a first difference variable, should the first difference explanatory variable be purged or should the current endogenous variable be purged, then a new first difference variable calculated from the purged variable and its actual lagged value? In most cases the latter procedure was adopted in this study.

Figure 4-3

Cattell's 'Scree Test' Criteria -
A Comparison of Characteristic Roots and Factor Number



These purged variables were then used instead of the original endogenous variables as explanatory variables in the second stage of the 2SLS process. It cannot be expected that the estimates derived from this Two Stage Principal Components (2SPC) technique will be as efficient as ordinary 2SLS. However, with large samples (where the number of components selected increases) the 2SPC estimates are consistent with the same asymptotic efficiency as 2SLS.²⁴

4-5 Summary

The basic model structure used in this study is a development of the simple cobweb model discussed in Chapter Two. That model was been extended to include stocks (so that changes in stock levels affect price determination), imports and exports. It has also been disaggregated to reflect the two different product "markets" at the retail level, the different characteristics of production in the two islands and for each of the three main slaughter grades, and price formation at both the farm and retail level. The resulting model is simultaneous with 20 equations, 16 of which are behavioural and described in detail in the next five chapters. These developments of the simple cobweb model were considered necessary to adequately reflect the structure of the New Zealand pig-meat market in a manner that is useful to policy-makers in the industry.

The choice of estimation technique appropriate for estimating the specified model was also discussed. Of the simultaneous equation techniques applicable to overidentified models 2SPC was chosen because of the relative simplicity and robustness of the 2SLS technique and the problems inherent in attempting to estimate a model including 69 predetermined variables with only 43 observations. Nine principal components which explained 87 percent of the variance in the predetermined variable set were chosen to replace the predetermined variables as instruments in the first stage of the 2SLS process.

24. P. J. Dhrymes, Econometrics, Harper and Row, 1970 pp 268-272.

CHAPTER FIVE

THE RETAIL DEMAND EQUATIONS:

SPECIFICATION, ESTIMATION AND EVALUATION

5.1 Introduction

This chapter discusses the specification, estimation and evaluation of the retail demand equations for both fresh and cured pig-meat. The first section briefly discusses recent changes in annual consumer expenditure on meat and other foods in New Zealand as well as changes in the composition of the meat market. The second section reviews a number of surveys of consumers' demand for meat with special emphasis on the importance of survey findings for the specification of the retail demand equations. The third section reviews the econometric estimates of pig-meat demand equations for New Zealand made by both Yandle¹ and Court.² The fourth section describes the specification and estimation of the demand equations used in the New Zealand Pig-Meat Model. Finally, the parameter estimates yielded by the estimation procedure are evaluated against economic 'a priori' criteria, statistical criteria and econometric criteria. The stability of these estimates is also considered.

5.2 Recent Changes in Consumer Demand for Food in New Zealand

Table 5-1 illustrates the changes in average real weekly expenditure on food for the period 1974 - 1979. Although earlier figures are unavailable, the figures in this Table

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1. C. A. Yandle, An Econometric Study of the New Zealand Meat Market, 1968.
 2. R. H. Court, "Utility Maximisation and the Demand for New Zealand Meats", Econometrica, Volume 35, No.3-4, July-October 1967, pp 424-446.

Table 5-1

Average Real Weekly Expenditure on Food
(deflated by CPI, expressed in March Year 1979 dollars)

Commodity	March Years					
	1974	1975	1976	1977	1978*	1979*
Fruit and Vegetables	5.37	5.15	5.82	5.37	5.19	5.02
Meat	8.41	6.80	6.97	7.09	6.38	6.31
Poultry and Fish	1.40	1.50	1.46	1.44	1.46	1.52
Dairy Products	4.25	3.85	4.05	4.43	4.31	4.18
Other Foods	13.39	13.14	14.44	14.89	14.90	14.79
Total Food	32.82	30.46	32.75	33.22	32.26	31.82
All Expenditure Groups	186.87	171.39	183.63	183.77	127.56	123.34
Percentages of Expenditure on Food						
Fruit and Vegetables	16.37	16.90	17.80	16.20	16.10	15.80
Meat	25.62	22.30	21.20	21.30	19.80	19.80
Poultry and Fish	4.26	4.90	4.40	4.30	4.50	4.80
Dairy Products	12.94	12.60	12.40	13.30	13.40	13.10
Other Foods	40.80	43.10	44.10	44.80	46.20	46.50
Total Food	100.00	100.00	100.00	100.00	100.00	100.00
Food % Total Expenditure*	17.60	17.80	17.80	18.10		
				25.90	25.30	25.80

* Unfortunately, because some of the non-food items were incomplete, total expenditure for 1978 and 1979 cannot be compared to previous years. However, the Department of Statistics has made figures available which allow a comparison of food % total expenditure with previous years.

Source: Department of Statistics, Household Survey Report, 1973/74, 1976/77, 1977/78.

illustrate some important trends. Total expenditure on food (deflated by the Consumers Price Index for all groups) has demonstrated considerable stability over the period when expressed as either expenditure per week or as a proportion of total expenditure. In contrast to this stability, expenditure on all meat as a proportion of total expenditure on food has shown a steady decline throughout the period.

Average real expenditure on all meat for the years 1977-1979 was approximately 9 percent lower than the average for 1974-1976 while the average proportion of food expenditure spent on all meat fell from 27.5 percent for the 1974-1976 period to 24.8 percent for the 1977-1979 period. It would appear that householders have reallocated a relatively fixed food budget away from meats and in favour of "other foods" (e.g. cereals). This raises important questions concerning the degree of substitutability between meat and other types of food. This substitutability has been ignored in previous studies of the retail demand for meat in New Zealand.³ It is possible that consumers did not consider other types of food as substitutable for meat in the 1950s and 1960s and that high meat prices (or the popularisation of vegetarian and macrobiotic diets) have stimulated a change in attitudes in the 1970s. However, this study also assumes that non-meat foods are not important substitutes for pig-meat. This study also assumes that consumers do not perceive of different types of meat as a homogeneous product (e.g. consumers are not discouraged from eating pig-meat because of their perceptions of aggregate "meat" prices). This assumption may be incorrect. The existence of homogeneity of this type would seriously effect the results presented in this chapter because it implies a degree of complementarity between different types of meat.

The other important trend revealed in Table 5-1 is the relatively constant expenditure (both in absolute and proportional terms) expended on white meats. The decline

3. See C. A. Yandle, op cit, and R. H. Court, op cit.

in expenditure on meat has fallen exclusively on red meat. The demand for different types of meat throughout the 1970s is shown in Table 5-2. A striking feature of this table is the very strong increase in per capita consumption of poultry

Table 5-2

Estimated Per Capita Consumption
of Meat in New Zealand 1970-1979

Year	Per Capita Consumption (kg)						Per Capita (kg)				
	Beef & Veal	Mutton & Lamb	Pig-Meat Stats.	Other (inc. Offal) Adj.*	Total Red	Pig-Meat % Red Meat	Poultry	Fish	Total Meat	Pig-Meat % Total	
1970	47	4.1	14	14	5	107	13.1	6	6	119	11.8
1971	46	41	14	15	6	108	13.9	6	7	121	12.4
1972	46	44	15	15	6	111	13.5	6	5	122	12.3
1973	49	43	12	13	6	110	11.8	7	4	121	10.7
1974	48	39	11	13	5	105	12.3	11	6	122	10.6
1975	53	38	12	13	5	109	11.9	12	4	125	10.4
1976	56	33	11	14	6	109	12.8	11	4	124	11.3
1977	59	30	12	14	5	108	12.9	13	3	124	11.3
1978	60	31	13	14	5	110	12.7	-	-	-	-
1979	53	31	12	14	5	103	13.5	-	-	-	-

Pig-meat consumption figures used in this thesis (see Appendix A for a discussion of the difference between these figures and those of the Department of Statistics).

Source: Derived from Total Consumption using Population figures for 31 March (Monthly Abstract of Statistics, May 1980) except poultry and fish figures which are published in the Official New Zealand Year Book, selected years.

meat throughout the decade compared to a relatively static demand for red meats. Both Yandle and Court ignore any relationship between the demand for red and white meats.

This may have been a reasonable assumption for the 1950s and 1960s when poultry consumption was extremely small (e.g. per capita consumption of poultry meat was only 1.8kg in 1955 and 1960 and had only climbed to 2.3kg by 1965). However, this would be an unreasonable assumption in the light of the data presented in Tables 5-1 and 5-2. Per capita consumption of poultry meat more than doubled between 1970 and 1977 and is now as important as total pig-meat consumption and considerably more important than the consumption of fresh pig-meat (in 1977 only slightly more than 4kg per head of fresh pork was consumed compared to 13kg per head of poultry meat). In making this type of comparison it is the size of the fresh pork market that is important because poultry meat is not a substitute for cured pig-meat products. As both tables demonstrate, poultry meat has increased its share of both the domestic meat market and (in combination with fish) total household expenditure on meat.

Table 5-2 shows that per capita consumption of pig-meat has remained virtually static throughout the 1970s in absolute terms and as a proportion of the meat market. This conclusion must be contrasted with that of others who have used the Department of Statistics figures and concluded that per capita pig-meat consumption has been falling.⁴ The analysis of various data sources presented in Appendix A demonstrated why the Department of Statistics figures are subject to error and why they would underestimate actual consumption. This table demonstrates that (consistent with a priori expectations) this bias has become more important with time. This virtually static level of per capita demand for pig-meats indicates that any positive effect that increasing per capita income has had on the demand for pig-meat has been completely off-set by an increase in the price of pig-meat relative to competitive products and/or the influence of "non-price" factors (e.g. changes in consumer attitudes). The influence of non-price

4. See, for example, R. J. Brodie, "Meat: A Consumer Survey of Christchurch Households", Agricultural Economics Research Unit, Research Report No.82, Lincoln College, 1977, p.37.

factors have been ignored in this study because of the difficulty involved in measuring this influence. However, this does not deny the influence of these factors on the pattern of demand for meat in New Zealand. The dramatic increase in poultry consumption must, in part, be due to the marketing effort directed towards this product. The adoption of the marketing plan proposed for the pig industry⁵ is also likely to increase the demand for pig-meat independently of relative price and income movements.

5.3 Surveys of Meat Consumers' Behaviour

This section reviews two recent surveys of meat consumers and, where appropriate, compares the results with Yandle's 1965 survey.⁶ Both the Yandle and Brodie studies were conducted in Christchurch. Yandle's mail survey questioned 361 persons on the Christchurch electoral rolls in September 1965.⁷ Brodie conducted an interview survey among 292 randomly selected Christchurch households during late April and early May 1977.⁸ The Pork Marketing Board also conducted an interview survey but sampled 600 "persons who buy meat for a household in the cities of Auckland, Wellington and Christchurch."⁹ This survey was conducted in December 1979. Despite these differences the findings of these three surveys, had a number of important similarities.

Both the Brodie and Pork Marketing Board surveys noted that pork was served infrequently. Of Brodie's sample, only 28 percent served pork regularly (at least every two weeks), 34 percent less regularly (had served pork in the last six months)

5. I. A. Lamb, Pork Marketing Board - Pork Industries Marketing Plan, June 1980.
6. See C. A. Yandle, op cit, R. J. Brodie, op cit, and I. A. Lamb, op cit.
7. C. A. Yandle, op cit, pp 25-27
8. R. J. Brodie, op cit, pp 1-4
9. I. A. Lamb, op cit p.28. For a review of the survey results see Lamb, op cit, p.28-31.

and 37 percent rarely or did not serve pork. The Pork Marketing Board survey showed that 45 percent of respondents did not serve pork often and about 33 percent hardly ever served pork.

All three surveys indicated that people consider pork an "expensive" food. Seventy-two percent of Yandle's respondents considered that pork was too expensive for everyday eating and, in answer to a separate question, respondents considered pork the most highly priced meat (which was incorrect at the time). Yandle noted that:

"It is possible therefore that consumers wrongly think that pork is both highly priced and expensive ... (although) consumers think pork is more highly priced than poultry ... the price of poultry was 16 pence per pound more than pork at the time of the survey."¹⁰

Brodie's results also indicate that people consider pork too expensive because large proportions of respondents who preferred pork did not serve it regularly. Brodie also discovered that there had been a significant swing away from sheepmeats and pork towards beef during the year prior to his survey but that:

"the swing away from pork has occurred despite it becoming "cheaper" during the year prior to the survey (its price had remained constant whereas sheepmeat and beef had increased 20-50 percent and 12-15 percent in price respectively)".¹¹

The Pork Marketing Board survey also found that consumers, especially light users of pork, considered pork "too dear" and that a large number of consumers also considered that pork was appropriate for "special occasions" rather than "everyday meals".

10. C. A. Yandle, op cit, p.35 and p.36.

11. R. J. Brodie, op cit, p.38.

The evidence that a large number of consumers are "infrequent" pork eaters and that pork is considered more appropriate for "special occasions" than "everyday use" suggests that there is very little habit persistence in pork consumption. Other factors being equal, consumers are likely to adjust their consumption relatively quickly in response to price and income changes. This evidence therefore suggests a static rather than dynamic formulation for the pork demand function. However, evidence presented by both Yandle and Brodie suggests that some insensitivity to actual relative price levels accompanies the infrequent use of pork. The perception that pork is expensive appears to persist even when the actual price of pork is less than meats considered "cheaper" (Yandle) or in the face of a relative price movement which improves pork's competitive position (Brodie's observation of a "perverse" reaction to relative price changes). This could be construed as a lagged response to price which would suggest that a dynamic formulation for the pork demand function is, in fact, appropriate.

It is difficult to choose between a dynamic and static formulation for the pork demand equation on the evidence presented here. Yandle's respondents may not have compared the price of poultry and pork on a per pound basis (even though the question asked them to use this criteria). They may have considered that pork was more expensive per serving and, therefore, may have had a correct perception of "price". It is also possible that the "perverse" response noted by Brodie was in fact a response to some third factor (e.g. a reduction in real incomes having a more dramatic effect on pork than other meats). The suggestion that there may be a lagged response to price changes because of some residual perception of pork's "expensiveness" implies that infrequent users do not regularly compare the price of pork with other meats. This could be a reflection of the frequency with which infrequent users are exposed to relative price information. However, evidence from the Pork Marketing Board survey indicates that:

"40 percent of consumers form purchasing intentions at home, 29 percent do this but change their minds in store; 31 percent form intentions in store. Research suggests that higher proportion of pork buyers form intentions in store."¹²

This would suggest that a large number of pork buyers regularly reappraise their decision to purchase pork.

All three studies indicate that the quantity of meat consumed is sensitive to income. In Yandle's survey, 36 percent of respondents indicated that they would increase their expenditure on pork following an increase in income (this response was second only to that for poultry), 62 percent would not alter their consumption levels and 2 percent indicated that they would buy less. Brodie's survey indicated that, of those people who had changed their level of meat consumption changes in price and income were the first and second most frequent reasons given for the change. The Pork Marketing Board survey results indicated that "... consumption is not closely associated with occupation per se but with income". The Household Survey Report¹³ also indicated that average weekly expenditure on meat increased as the total weekly income of the household increased (although meat expenditure tended to fall as a proportion of total expenditure as income increased). Although these results indicate that the consumption of pork is likely to be sensitive to income they do not indicate the form this relationship takes. The indication that consumers consider pork more appropriate for "special occasions" than "everyday use" suggests that pork consumption may be a function of the change rather than the level of income.

Both Yandle and Brodie also included questions about bacon and ham consumption in their surveys. Brodie found that:

12. I. A. Lamb, op cit, p.30

13. Department of Statistics, Household Survey Report Year Ended March 1977, p.15.

"29 percent of households served ham regularly compared with 61 percent for bacon; with 69 percent serving ham and 84-percent serving bacon every 6 months ... Consumption was characterised by a larger proportion of households in the tradesman and labourer group and older age groups consuming the meats regularly."¹⁴

Twenty-one percent and 34 percent of Yandle's respondents indicated that they would buy more bacon and ham respectively in response to an increase in income. This result indicates that, for Yandle's sample, the income elasticity of demand for pork could be higher than for bacon and ham. However, it is difficult to deduce a great deal from these results. Seasonal factors have a relatively strong influence on bacon and ham consumption with bacon consumption increasing in the winter months and ham consumption in the summer months.¹⁵ Therefore it would be difficult to argue that habit persistence is a significant factor in combined bacon and ham consumption even though a large number of Brodie's respondents consumed bacon regularly.

These three cross-sectional surveys have been used to help specify demand functions for pig-meat by indicating which variables should be included in these functions, the relative importance of these variables, and the mathematical form of the relationships involved. These surveys indicate demand for pig-meat (especially for pork) is sensitive to pig-meat prices and income and that the effect of price changes is likely to be more important in determining demand than the effect of income changes. There is also some evidence to suggest that demand may be a function of the change rather than the level of income. These surveys also provide valuable evidence on the likely importance of lagged responses in consumer demand for pig-meat (and therefore whether a static or dynamic formulation of the demand function is appropriate). Although the evidence tends to indicate that habit persistence

14. R. J. Brodie, op cit, p.13.

15. This conclusion of Yandle's (Yandle, op cit, p.125-6) has been supported by conversation with a number of processors. Ham consumption would appear to be more influenced by seasonal factors than bacon consumption.

is not an important feature of pig-meat demand, it cannot be used to exclude a dynamic formulation from further consideration.

5.4 Review of Previous Studies

Labys notes that:

"Probably no other aspect of the specification and estimation of commodity behavioural relationships has received as much attention as that of demand".¹⁶

This section does not attempt to review the major developments in the specification and estimation of demand relationships. Excellent reviews of these developments are available elsewhere.¹⁷ This section confines itself to a discussion of two studies directly relevant to the specification of a retail demand for pig-meat relationship for New Zealand; the econometric analyses of the retail demand for meat in New Zealand by both Court and Yandle.

Court's study of the New Zealand meat market is atypical because his estimates of the demand sub-system were subjected to symmetry restrictions which were later tested.¹⁸ His demand functions were derived from the utility theory of consumer demand (i.e. a consumer is assumed to maximise his utility subject to a budget constraint). These functions related consumption of beef, mutton and pig-meat to the price of each meat, the price of the other two meats, the prices of all other items in the consumers budget (i.e. the retail price index), and to income per head:

16. W. C. Labys, Dynamic Commodity Models, 1973, p.7

17. See, for example, W.G. Tomek and K. L. Robinson, "Agricultural Price Analysis and Outlook", in A Survey of Agricultural Economics Literature, Volume One, edited by L. R. Martin, Minnesota Press, 1977, p.336-351 and W. C. Labys, op cit, p.7-34.

18. Symmetry restrictions demand that the cross price elasticities for two goods must be equal when weighted by the increase of their respective relative expenditure weights and summed with the income elasticity of the good.

$$\frac{x_i}{N} = d_i \left(\frac{P_1}{P}, \frac{P_2}{P}, \frac{P_3}{P}, \frac{M}{NP}, u_i \right) \quad i = 1, 2, 3$$

where subscripts 1, 2 and 3 represent beef, mutton and pig-meat respectively, x_i represents total consumption, P_i is the retail price of the i th meat, N is population, M is total personal expenditure on consumer goods and services, and u_i is a random error".¹⁹

This set of equations was then estimated both with and without symmetry conditions applied using a sample of annual data from 1950 to 1960 inclusive. Elasticities estimated by regression for the pig-meat equation both with and without symmetry conditions applied are given in Table 5-3.

Table 5-3

Elasticities of Court's Annual Pig-Meat Demand Equation
With and Without Symmetry Restriction Applied

	<u>Own Price</u>	<u>Cross Price Beef</u>	<u>Mutton</u>	<u>Income</u>	<u>R²</u>	<u>DW*</u>
Without Restrictions (standard errors)	-1.251 (0.29)	0.547 (0.25)	0.792 (0.42)	0.968 (0.41)	0.83	2.76
With Restrictions (standard errors)	-0.552 (0.15)	0.363 (0.16)	-0.056 (0.15)	1.251 (0.51)	0.66	1.85

* Durbin-Watson statistic

Court also used these estimated relationships to predict consumption levels for 1961-1963 and found that the equations estimated under the symmetry restrictions gave better predictions than the unrestricted regression equations. Court concluded that the application of the symmetry restrictions was, in his case, both valid and useful.

19. R. H. Court, op cit, p.436

Yandle estimated a number of alternative specifications for meat demand relationships in New Zealand using quarterly data for the period 1950 (fourth quarter) to 1965 (fourth quarter). Like Court, Yandle expressed per capita consumption for mutton and beef as a function of the price of beef, mutton and pork, the consumer price index and income per head with seasonal dummies used to account for seasonal influences. However, as already noted, Yandle considered the demand for pig-meat predetermined and therefore the retail price of pig-meat was expressed as a function of the quantity demanded rather than *visa versa*. Unlike Court, Yandle considered that the retail fresh meat market was distinct from the retail cured meat market:

"Ham and bacon have not been included in the New Zealand meat model, their parameters were estimated in a separate model because ham and bacon are not major competitors of the main meats. The results of the consumer survey clearly show this lack of competition"20

Yandle also preferred a dynamic formulation of the demand equation rather than the static formulation used by Court (although both formulations were tested by Yandle). These two approaches could be reconciled because of the different periodicity of the data used in each study; consumers may fully adjust their level of consumption to price or income changes within a year without necessarily adjusting fully within any one quarter. Yandle's best estimates of the short and long run demand for pig-meat are given in Table 5-4.

Unfortunately neither of Yandle's equations for pig-meat are very satisfactory:

"The reduced-form pork demand equation was the least satisfactory of the OLS equations in this model. The coefficient of determination, although significantly different from zero, does not allow

great confidence in the use of the equation to explain future equilibrium demand levels.... In addition, the von Neuman ratio indicates serious positive autocorrelation"²¹

Yandle, like Court's restricted model, found an insignificant (and negative) cross elasticity between pork and mutton which implies that some degree of complementarity may exist between these two products or, more probably, they are not directly competitive. The pork elasticities all appear to be rather large which would indicate that pork consumption is extremely sensitive to price and income changes. The striking feature about the long run elasticities is their size relative to the short run elasticities. Yandle notes that:

"The pork demand adjustment coefficient was however greater than unity, taking the value of 1.609 ... Essentially the interpretation must be that consumers have 'over-reacted' to the change in market forces, during the first time period moving the quantity demanded past the equilibrium point."²²

Table 5-4

Short and Long Run Elasticities of Yandle's
Quarterly "Pork" and "Bacon and Ham"
Equations (OLS estimates)

	Own Price	Cross Beef	Price Mutton	Income	R ²	K*
Pork - Short Run	- 9.09	1.27	- 0.78	1.93	0.45	0.67
- Long Run	- 5.65	0.79	- 0.48	1.19		
'Bacon and Ham'						
- Short Run	-28.57 [#]	N/A	N/A	16.88	0.51	0.30
- Long Run	-25.00 [#]	N/A	N/A	14.77		

* K = von Neuman ratio

Not significant

21. Ibid, p.220

22. Ibid, p.232

Yandle fails to offer a behavioural hypothesis that would result in this "over-reaction" and it is extremely difficult, especially on the cross-sectional data available, to determine why this over-reaction would have occurred.

Yandle's results for the "bacon and ham" equations were completely unsatisfactory:

"These models were; a dynamic, and a static, retail demand model. In neither case was the model at all satisfactory, suggesting that if data were available respecification of the "ham and bacon" models would be desirable".²³

Income is the only variable which had a coefficient significantly different from zero, a "barely acceptable" level of variance had been explained, and there is a strong indication that positive autocorrelation is present.

These two time series studies provide additional evidence to use when specifying the demand functions for pig-meat in the model. Both studies provide additional evidence which enables a better identification of the variables which should be included in the demand function and the relative importance of these variables in determining demand. Both studies show a strong negative association between the demand for pig-meat and its price although Court's restricted equation indicates that the absolute value of the income elasticity is larger than that for the price elasticity. Both studies also indicate that mutton is not a competitive product. Although Court uses a static formulation while Yandle adopts a dynamic formulation, the two approaches are not necessarily inconsistent. However, Yandle's results do not confirm the partial adjustment hypothesis.

23. Ibid, p.258

5.5 Specification and Estimation of the Retail Demand Equations Used in the New Zealand Pig-Meat Model

The general specification of the demand relationship derived from consumer utility theory and explained by Court above has been used in this study. Although some assumptions had to be made concerning the allocation of various slaughter classes to the fresh and cured "markets" the clear distinction between these two markets demanded that some attempt be made to specify a separate demand relationship for both fresh and cured products. The important assumptions are that all pork and chopper weight pigs are consumed "fresh" and that all bacon weight pigs are "cured" (although the use of a dummy variable to account for the changes in weight range classification in 1973 does allow some relaxation of this assumption.) This assumption is bound to have resulted in some measurement error but is the best distinction that could be made on the data available.

Beef and poultry meat are assumed to be fresh pork's major market competitors. As already noted, poultry consumption has increased dramatically since the Court and Yandle studies and is now likely to be a major competitor on the meat market. Mutton has been excluded from consideration as a competitive meat. Both the Court and Yandle studies found that the cross price elasticity between pork and mutton was insignificant. There is no evidence to indicate that mutton can now be regarded as a competitive product. Bacon and ham are not assumed to have any major competitive or complementary products associated with them (an assumption also adopted by Yandle in the specification of his "bacon and ham" model).

The consumption of both pork and cured pig-meat is assumed to be sensitive to per capita income although it is difficult to determine the form of this relationship on a priori grounds. Both the level and percent change in the level of income were used as explanatory variables and only the percent change

variable was significant. This implies that consumers will alter their consumption in response to a change in income rather than implying that a given level of income can be associated with a given level of per capita consumption. This is consistent with some of the evidence from the consumer surveys.

Apart from the respective products own prices, dummy variables to explain seasonality and to account for the change in classification of porker and baconer pigs in the third quarter of 1973 are the only other explanatory variables used. The use of a dummy variable to allow for a shift in the intercepts as a consequence of this reclassification of slaughter pigs acts to relax the rather rigid assumption that all bacon weight pigs enter the cured meat market (which is far less likely to remain valid in the face of a change in weight classification which arbitrarily graded more pigs into the baconer weight range). There is some evidence that the limited number of baconer pigs that do enter the fresh pork market has increased since this classification change.²⁴ Therefore, we would expect the coefficient for this dummy variable (which is set to unity for the period prior to the change) to be positive in the fresh meat equation and negative in the cured meat equation. Finally, it appears that the change from dairy by-product to grain based ration feeding of pigs has had an important influence on the seasonal nature of demand. Although this is difficult to explain on a priori grounds, this influence has been accounted for by introducing a fourth seasonal dummy variable (that allows a change in third quarter intercept post 1973) into the demand equations.

Although the a priori evidence in either direction is weak, there is certainly no good reason to suppose that the retail demand functions should be dynamic rather than static in nature. // Although Yandle prefers the dynamic formulation, his results show a "perverse" dynamic result for pig-meat (i.e. that consumers "over-react" rather than partially

24. I. A. Lamb, op cit, p.8.

adjust to the equilibrium level of consumption). Given these results it was decided to adopt a static formulation but to test for the presence of dynamic behaviour by respecifying and re-estimating the equations.

Given the discussion above, the per capita consumption of fresh pig-meat was assumed to be a function of the real retail price of pork, the real retail price of beef and poultry, the percentage change in the level of real per capita income, three seasonal dummies and two structural dummies (to represent the change in grade classification and the influence of grain feeding on seasonality). All prices and income were deflated using the Consumers Price Index which represents the influence of all other items in the consumers budget. Per capita consumption of cured pig-meat was assumed to be a function of the real retail price of "bacon and ham", the percentage change in real per capita income, and the five dummies used in the fresh meat equation.

These two equations were estimated using quarterly observations for the period 1970 (first quarter) to 1979 (second quarter) using 2SPC. Although the values for the parameters were acceptable the Durbin-Watson statistic was in the inconclusive range for both equations which indicated that autocorrelation may have been present. The equations were therefore re-estimated using the Cochrane-Orcutt Iterative Technique²⁵ in the second stage regression to remove the suspected autocorrelation (i.e. 2SPC (CORC)). These results are presented in Table 5-5 and compared to a 2SPC estimation of the dynamic specification for both equations. All the price variables shown are retail prices and all variables prefixed with a 'D' are dummy variables (where D_i = dummy variable for quarter i , $i = 2, 3, 4$).

25. The Cochrane-Orcutt Iterative Method estimates (by an iterative process) the autocorrelation coefficient $\hat{\rho}$ (rho) where autocorrelation is assumed to be of the first order:

$$U_t = \rho U_{t-1} + V_t$$

Table 5-5

A Comparison of the Parameter Estimates and Static and Dynamic Formulations of the Fresh and Cured Pig-Meat Retail Demand Equations

EXPLANATORY VARIABLE	EQUATION AND ESTIMATION TYPE					
	Per Capita Fresh Pork Consumption			Per Capita Cured Pig-Meat Consumption		
	Static		Dynamic	Static		Dynamic
	2SPC	2SPC (CORC) ^k	2SPC	2SPC	2SPC (CORC) ^k	2SPC
Constant	1,462.0	1,377.5	1,045.1	3,684.5	3,569.6	3,482.2
DRPK	-7.38 (1.26)	-6.12 (1.48)	-4.89 (2.49)	-	-	-
DRBEEF	1.87 (0.87)	1.196 (1.06)	0.831 (1.24)	-	-	-
DRPPY	4.32 (0.96)	3.86 (1.20)	3.09 (1.42)	-	-	-
DRBC	-	-	-	-2.41 (0.58)	-2.20 (0.71)	-2.26 (0.72)
CHYPC	138.17 (445.1)	258.2 (372.7)	174.4 (443.6)	1,084.2 (553.8)	1,037.9 (486.5)	1,120.3 (596.5)
D20Q	315.32 (85.6)	378.79 (98.85)	295.3 (86.9)	-554.3 (57.6)	-515.5 (68.7)	-527.5 (90.79)
D2	105.01 (81.2)	86.6 (67.4)	103.2 (80.7)	59.49 (101.62)	49.3 (88.7)	70.8 (107.2)
D3	27.06 (76.55)	-1.04 (64.9)	10.4 (77.4)	298.7 (96.95)	294.4 (86.4)	300.11 (98.4)
D321	-239.4 (81.6)	-214.14 (68.2)	-265.5 (84.3)	-405.4 (101.8)	-430.1 (90.7)	-400.7 (104.0)
D4	82.16 (81.17)	67.8 (67.11)	90.8 (81.0)	221.4 (100.9)	209.9 (87.9)	225.4 (102.9)
Lagged Consumption	-	-	0.266 (0.23)	-	-	0.046 (0.12)
Rho (\hat{p})		0.367 (0.15)			0.229 (0.16)	
R ²	0.937	0.941	0.940	0.888	0.888	0.888
DW	1.44	1.82	1.62	1.53	1.91	1.58

where: DRPK = Real Retail Price Pork
 DRBEEF = Real Retail Price Beef
 DRPTY = Real Retail Price Poultry
 DRBC = Real Retail Price Bacon
 and Ham

CHYPC = Real Change in Income
 Per Capita
 D20Q = Grading change dummy
 D321 = Changing Seasonality
 dummy

Figures in brackets are standard errors

Of the three "fresh pork" demand equations estimated the static 2SPC (CORC) equation was adopted to explain per capita fresh pork consumption in the New Zealand pig-meat model.

The dynamic specification of this equation had to be rejected because the value of the lagged dependent variable coefficient was not significantly different from zero even at the 20 percent level of confidence. Thus in this "partial adjustment" model (in which this coefficient is equal to one minus the adjustment coefficient) the adjustment coefficient is not significantly different from one and consumers adjust fully to their equilibrium position within one quarter.

Of the three 'cured pig-meat' demand equations estimated the 2SPC (CORC) equation was also chosen although this choice was less straightforward than that discussed for fresh pork above. The dynamic formulation can be rejected immediately because of the extremely insignificant value for the lagged dependent variable coefficient. The choice between the 2SPC and the 2SPC (CORC) equations is considerably more difficult. The first point to note is that the two sets of parameter estimates are not significantly different from each other. Secondly, although the Durbin-Watson statistic for the 2SPC equation is low it is very close to the lower boundary of acceptability in the Durbin-Watson test at the 1 percent level of significance (i.e. 1.53 is only slightly less than $du = 1.59$). Thirdly, although the Durbin-Watson statistic definitely improves with the application of the Cochrane-Orcutt technique, the standard error of \hat{p} is high and \hat{p} is only significant at the 20 percent level. Although there is very little to choose between the 2SPC and 2SPC (CORC) equations, the 2SPC (CORC) equation was chosen to avoid the risk of accepting an equation with autocorrelation.

Both of the accepted equations have been transformed by the Cochrane-Orcutt technique in an effort to avoid auto-

correlation. This means that these equations are no longer of the form:²⁶

$$Y_t = b_0 + b_1 X_{1t} + \dots b_k X_{kt} + U_t$$

$$(\text{where } U_t = pU_{t-1} + V_t)$$

but has actually been transformed into the form:

$$Y_t^* = A_0 + A_1 X_{1t}^* + \dots A_k X_{kt}^* + V_t,$$

$$(\text{where } V_t \text{ is a random variable})$$

where:

$$Y_t^* = Y_t - \hat{p}Y_{t-1},$$

$$X_{jt}^* = X_{jt} - \hat{p}X_{j(t-1)}, (j=1 \dots \dots)$$

$$V_t = U_t - \hat{p}U_{t-1}$$

$$A_0 = (1 - \hat{p}) b_0.$$

There may be some problems inherent in applying this technique to these equations and other equations in the model. Auto-correlation may be due to a number of factors (e.g. omitted explanatory variables, a mis-specification of the functional form of the equation, measurement error) in addition to true autocorrelation. Although considerable care has been taken to correctly specify the relationships in the model it is possible that the Cochrane-Orcutt technique has been applied when some other approach (e.g. including a larger number of explanatory variables or changing the functional form of the equation) would have been better. Secondly, the Cochrane-Orcutt transformation changes the hypothesised (in this case, linear) relationship between the dependent and independent variables and, therefore can change the interpretation of the estimated coefficients. As \hat{p} approaches one the transformed relationship approaches a first difference form.

26. For a rationalisation of this transformation procedure see A. Koutsayiannis, op cit, p.218.

5.6 Evaluation of the Parameter Estimates

There are three broad groups of criteria that are used to evaluate parameter estimates; economic a priori criteria, statistical criteria and econometric criteria.

Economic criteria are determined by economic theory and are concerned with the sign and size of the parameters and the derived elasticities. All of the parameters in both equations have the expected sign; per capita consumption is negatively related to 'own price' and positively related to the price of competitive products and income. The only unexpected result is that the income coefficient in the fresh pork equation is not significantly different from zero. The 'D20Q' variable, which is used to dummy out the effect of the change in slaughter weight classification, is, as expected, negative for cured pig-meat and positive for fresh pork. This indicates that after the grading change, which arbitrarily placed more pigs in the 'baconer' weight range, there was an increase in the consumption of cured pig-meat that could not be explained by relative price and income movements. This implies that the assumption that all baconer weight pigs enter the cured meat market has resulted in an overstatement of per capita consumption of cured meat by an average of 0.5kg per person per quarter (or 22 percent of total consumption) after the grading change. This appears to be quite high and is not entirely consistent with the result from the fresh pork equation which implies that the fresh meat consumption has been understated by only 0.39kg per person per quarter after the grading change (although the two parameters sum to zero within their standard error ranges). If, as a result of the grading change, one kilogram of baconer carcass was diverted from the cured to the fresh market (and this assumes that wastage rates for alternative uses are the same) then the restriction that these two parameters (for D20Q in each equation) should sum to zero should be applied when these equations are re-estimated.

The interpretation of the seasonal dummies is complicated by the inclusion of D321 which was used to account for a changing seasonality pattern of consumption. For the fresh pork equation, the first quarter intercept is 1.33kg per person, the second quarter intercept is 5.8 percent higher (i.e. $1.377 + 0.086$), the third quarter intercept is not significantly different for the first quarter intercept for the latter (grain-fed) period but is significantly lower (i.e. -15.9 percent) for the earlier (dairy by-product fed) period, the fourth quarter intercept is not significantly different from that of the first quarter. These results indicate that seasonality has not been an important feature of fresh pork consumption since 1973, however there has been a change in the seasonal pattern of consumption with the pre-1973 third quarter drop in consumption not occurring post-1973. With respect to cured meats, seasonality in consumption and the change in this seasonality has been more marked. The first quarter intercept for cured pig-meats is 3.57kg per person, the second quarter intercept is not significantly different from the first, the third quarter intercept is 8.1 percent higher for the latter period but 12 percent lower for the earlier period, and the fourth quarter intercept is 6 percent higher than the first quarter intercept.

The 'own price', cross price and income elasticities implied by both equations are given in Table 5-6. These elasticities are credible. The 'own price' elasticities are similar to Court's and lower than Yandle's, and indicate that fresh pork consumption is far more sensitive to changes in the retail price of pork than cured pig-meat consumption is to changes in the retail price of bacon and ham. This is consistent with the wider range of substitutes to fresh pork and the large proportion of people who have a preference for pork but do not serve it regularly. This result

Table 5-6

Price and Income Elasticities Implied by
the Fresh Pork and Cured Pig - Meat Consumption Equations*

	<u>Own Price</u>	<u>Cross Price</u>		<u>Income</u>
		<u>Beef</u>	<u>Poultry</u>	
Fresh	-1.54	0.26	0.98	0.22
Cured	-0.52	4.56

* These elasticities are calculated at the mean values of the respective variables.

should prove very useful to policy makers in the industry who are contemplating increasing emphasis on the "one pig concept" and the diversion of more locally produced pig-meat onto the fresh pork market. This result indicates that moving pig-meat from the cured to the fresh market will actually increase consumer expenditure on both cured and fresh pig-meat. At average prices and quantities, diverting 1 percent of (potentially) cured product into the fresh market will increase the supply of fresh product by 1.9 percent and result in a 1 percent increase in total consumer expenditure on cured and fresh products combined.

The cross price elasticities indicate that fresh pork consumption is more sensitive to changes in the retail poultry price than it is to changes in the retail beef price (i.e. that consumers consider poultry more substitutable for pork than beef).²⁷ The cross elasticity with beef price is lower than both Court's restricted cross beef price elasticity for aggregate pig-meat consumption (0.36) and Yandle's cross beef price elasticity for pork consumption (1.2). However, given the impact that poultry meat has had on the meat market since both these studies were completed these results are not necessarily inconsistent.

27. However this conclusion appears to be sensitive to the estimation period chosen (see Table 5-7).

The income elasticity for fresh pork is very low (the income parameter was not significantly different from zero) which is a little surprising. Court's work suggests a unitary income elasticity for aggregate pig-meat consumption whereas Yandle's income elasticity for pork is close to two. The consumer survey results also suggest that the consumption of fresh pork should be sensitive to incomes. On the other hand the income elasticity for cured pig-meat is large. There is little a priori reason to either accept or reject this size of elasticity. Yandle's "unsatisfactory" 'bacon and ham' equation indicated that a considerably larger income elasticity for cured products was appropriate.

The most widely used statistical criteria for evaluating estimated relationships are the coefficient of determination (R^2) and the standard errors of the estimates. The coefficients of determination for both equations are shown in Table 5-5 and indicate that 94 percent and 89 percent of the total variation in the per capita consumption of fresh pork and cured pig-meat respectively is explained by the changes in the explanatory variables. The standard errors are also shown on Table 5-5. These statistics indicate that, of the parameters in the cured pig-meat equation only the dummy variable for the second quarter is not significantly different from zero at the 5 percent significance level. However, of the parameters in the fresh pork equation, the retail beef price, the income variable, and all of the seasonal dummy parameters (except D321) fail this test (although the beef price parameter is significant at the 20 percent level). The high standard error attached to the retail beef price parameter suggests that multicollinearity may be present. An inspection of the correlation coefficient matrix for the fresh pork equation shows that the correlation coefficient between the beef and poultry price is 0.678 which indicates that multicollinearity may be affecting the standard error of the beef price parameter. In this case, given reasonably strong a priori reasons why beef and pork

should be competitive, the high standard error associated with the beef price parameter should not result in this variable being rejected from the set of explanatory variables.²⁸

Finally, the stability of the parameter estimates for both equations was tested by re-estimating the equations using a smaller number of observations. It is arbitrary how many observations should be used so five observations were adopted from the end of the sample period and the equations estimated using 32 rather than the original 37 observations. The

Table 5-7

Testing the Structural Stability of the
Pig-Meat Demand Equations

n	Fresh Pork		Cured Pig-Meat	
	37	32	37	32
Constant	1,377.50	1,943.30	3,569.6	3,831.0
Pork Price	- 6.12	- 9.55	-	-
Beef Price	1.196	4.35	-	-
Poultry Price	3.86	2.84	-	-
Bacon Price	-	-	- 2.2	- 2.5
% Change Income	258.2	- 261.2	1,037.9	1,680.1
D20Q	367.79	173.4	- 515.5	- 560.6
D2	86.6	210.9	49.3	- 39.3
D3	- 1.04	139.4	294.4	240.4
D321	- 214.14	- 285.39	- 430.1	- 422.5
D4	68.8	193.8	209.9	153.4
e ²	270,974.0	179,325.0	460,409.0	404,564.0
F*	2.35		0.64	

* The critical value for F at 5% level is 2.80.

28. There is still considerable debate about what level of collinearity between explanatory variables constitutes a "problem" (See A. Koutsoyiannis, *op cit*, p.237). The relationship between beef and poultry prices may also affect the stability of the poultry price parameter (See Table 5-7)

changes in coefficients were then tested for significance using an F statistic.²⁹ The results for both equations are given in Table 5-7. Because the computed F statistic is less than the critical value (at the 5 percent level of significance) we accept that the structural coefficients in both equations are stable (i.e. do not change significantly as the sample size decreases from 37 to 32). However, an examination of Table 5-7 indicates that the equation for cured pig-meat is far more stable than that for fresh pork. Of particular interest is the dramatic increase in the beef price parameter and the reduction in the poultry price parameter. This gives further support to the conclusion that multicollinearity between these two prices may have affected the parameter estimates and standard errors. The individual cross price elasticities reported in Table 5-6 are likely to be unstable and should therefore be treated with suspicion.

29. For an explanation of this procedure see A. Koutsoyiannis, Theory of Econometrics, p.168.

CHAPTER SIX

THE FARM-RETAIL PRICE MARGIN EQUATIONS: SPECIFICATION, ESTIMATION AND EVALUATION

6.1 Introduction

This chapter discusses the specification, estimation and evaluation of the farm-to-retail price margin equations (margin equations) for both fresh and cured pig-meat. These equations model the behaviour of processors, wholesalers and retailers and are used in the model to link the four regional farm price equations to the two aggregate retail price equations. The first section stresses some of the important features of the wholesale and retail meat trade, concentrating on firms pricing behaviour and the incidence of price regulation. The second section reviews two econometric studies of meat marketing margins in Australia¹ and New Zealand². The third describes the specification and estimation of the margin equations used in the New Zealand Pig-meat Model. Finally the parameter estimates yielded by the estimation procedure are evaluated.

6.2 Features of the Wholesale and Retail Pig-Meat Trade

Some of the important features of the wholesale and retail pig-meat trade have already been discussed. Chapter Three discussed the competitive features of this trade.³ Chapter Four noted the different marketing procedures applied to fresh and cured products. The Pork Industry Council's Manual notes that:

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1. G. R. Griffith, "Sydney Meat Marketing Margins - An Econometric Analysis", Review of Marketing and Agricultural Economics, Volume 142, No.4, December, 1974, pp 223-239.
 2. G. R. Griffith, An Econometric Study of the New Zealand Meat Market, 1968.
 3. For a discussion of the competitive nature of the meat trade see the Report of a Committee of Inquiry into the Distribution of Meat, Fish, Fruit and Vegetation, 1973, pp 13-31 and p.48.

"Pigs for sale as fresh meat through butchers shops and supermarkets are mainly slaughtered at municipal abattoirs, and are either purchased direct by butchers, or through meat wholesale organisations, operating within a close range of the retail outlets Most process pigs (baconers) are purchased by one of the larger national companies, most of whom operate nationwide and use freezer facilities. As a result baconer carcasses may be moved long distances for ultimate use and sale."⁴

Not only are baconer pigs subject to considerably more processing than porker pigs, they are handled by different organisations, stored, and tend to be transported further than porker pigs. We would expect the margin on baconer pigs to be larger than that applied to porker pigs and subject to different cost influences.

Two additional features of the pig-meat trade need to be discussed; the pricing policies of traders and the incidence of price control during the estimation period. The pricing policies of traders are an extremely important determinant of the level of margin between farm and retail prices. Whether traders apply a fixed or proportionate mark-up on costs, reflect changes in costs promptly in retail prices, attempt to "average" margins across different types of meat and/or vary mark-ups with the volume of meat sold are all important pricing policy questions that need to be considered.⁵ Both theory and empirical observation indicates that changes in retail prices will tend to be slower and less dramatic than changes in farm prices. A certain amount of inertia in the

4. Pork Industry Council, Pig Production and Management Manual, Pork Industry Council, June 1977, Present Industry Schedule p.3.

5. The influence that changes in margins have on farm and retail prices is also important and is discussed in Chapter Seven.

marketing system is likely to account for some delay in transmitting price changes through this system. However, both Yandle and Griffith suggest that traders also practice price "levelling" and "averaging" in an effort to stabilise their prices.⁶ Griffith notes that this behaviour offers some advantages to traders if it is confined to the short run.

"This (i.e. a reasonably fixed and predetermined meat budget) would influence retailers to level prices to retain retail custom, since consumers would search for butchers with more stable prices if the prices at their traditional butchery fluctuated wildly. Relatively stable prices also save retailers and wholesalers costs by reducing uncertainty of throughput and thereby increasing administrative and operational efficiency. Apparently there are also high costs involved in changing prices and in letting customers know of these changes, so retailers especially are reluctant to alter their prices if they consider changes in wholesale prices to be only of short run duration."⁷

In his study of the Sydney meat market, Griffith also tested the proposition that traders' margins were independent of their turnover. This implies that fixed costs do not increase (decrease) with decreasing (increasing) turnover (assuming that the variable costs associated with producing marketing services are separately identified in margins equations).

Government imposed price controls have also been an important feature of the pig-meat trade throughout the estimation period. The Report of a Committee of Inquiry into the Distribution of Meat, Fish, Fruit and Vegetables discusses the history of price control on meats from 1939 to 1973.⁸ After 11 years of price

6. Price levelling refers to the practice of traders holding their price-selling prices stable in the face of rising or falling farm prices. Price averaging refers to the practice of taking a low margin on one type of meat and recouping any loss by setting a higher margin on other types of meat. Yandle notes this behaviour in New Zealand (C. A. Yandle, *op cit*, p.12).

7. G. Griffith, *op cit*, p.235

8. On pages 31-40.

control during and immediately post war, the Government decided to decontrol meat in May 1950. Following decontrol meat prices increased substantially and the rapid increase in retail prices of meat (even when compared to wholesale price movements) between 1949-59 prompted Government to recontrol meat prices in early 1960. After two years of stable prices control was lifted in 1961. Since 1961 the Government has intervened on a number of occasions in an attempt to control the retail prices and wholesale and retail margins of pig-meat.⁹

1. Price Freeze Regulations 1968 - from 21 June 1968 to 17 August 1968, the prices were frozen (this does not affect our estimation period).
2. Price Freeze Regulations 1970 - from 17 November 1970 to 17 January 1977, the prices of bacon and ham as at 12 November 1970 were frozen. Fresh or frozen meats were exempt.
3. Price Justification Scheme (Price Order No.2154) - from 15 February 1971 to 27 March 1972, the prices of bacon and ham were controlled (the prices of fresh pork were exempt). In addition, all wholesalers' and retailers' margins (on fresh and cured pig-meat) were restricted to their level on 21 November 1970.
4. Price Freeze Regulations 1972 - from 14 February 1972 to 31 March 1972, the prices of bacon and ham as at 14 February 1972 were frozen (fresh pork was exempt).
5. Stabilisation of Prices Regulations 1972, 1973 and 1974 - the prices of bacon and ham were controlled between 1 April 1972 and 6 April 1979

9. This information, on the incidence of price control since 1961, was obtained from the Department of Trade and Industry.

(fresh pork was exempt). Wholesalers' and retailers' margins were restricted to their established levels at certain dates (31 March 1972, 14 November 1973 and 14 July 1974 respectively).

6. Price Freeze 1976 - from 18 August 1976 to 14 May 1977 the prices of bacon and ham were frozen (fresh pork was exempt).
7. Price Surveillance Regulations 1979 - the prices of pig-meats have been subject to surveillance since 6 April 1979.

There is little a priori evidence available on the effectiveness of these various measures. As already noted, competition in the trade should automatically act to moderate increases in prices and margins. The effective control of margins is also very difficult to achieve because of the problems inherent in policing the regulations. However, the influence of price control cannot be ignored in any analysis of pig-meat margins over the period.

6.3 Review of Previous Studies

Yandle's study of the New Zealand meat market includes an analysis of retail margins applied to meat products in New Zealand using quarterly data from 1953 to 1965. His specification of these margin relationships is basically the same as that used by Fuller and Ladd¹⁰ in their 1960 study of the United States meat market. Yandle's estimating equation for pork was:¹¹

10. W. A. Fuller and G. W. Ladd, "A Dynamic Quarterly Model of the Beef and Pork Economy", Journal of Farm Economics, Volume 43, 1961, pp 797-812.

11. C. A. Yandle, op cit, p.122

$$M_{pt} = P(I_t, W_{Pp_t}, Z_1, \Delta W_{Pb_t}, \Delta W_{Pm_t}, \Delta W_{Pp_t}, M_{pt-1})$$

where:

M_p	= Wholesale-to-Retail Margin on pork
I	= Index of Butchers' Wage Costs
W_{Pp}	= Wholesale price of pork
$\Delta W_{Pb}, \Delta W_{Pm}, \Delta W_{Pp}$	= Change in the wholesale price of beef, mutton and pork respectively.
Z_1	= Shift variable for the period of price control in 1959/60
M_{pt-1}	= Lagged dependent variable

His 'bacon and ham' margin equation had a similar specification except that the change in the wholesale price of mutton and beef were excluded (i.e. no price averaging was assumed to have influenced 'bacon and ham' margins).

This estimating equation is derived by substituting an equation defining the equilibrium wholesale-to-retail margin into an equation which defines the actual change in margins. Yandle's equilibrium wholesale-to-retail margin is a function of wages (representing marketing costs) and the wholesale price of the product (representing a proportional mark-up) and a constant term (representing a fixed component of the margin). The actual change in margin is then assumed to be a proportion of the desired change in margin (reflecting partial adjustment) and the change in the wholesale price of the product (representing price levelling) and the change in the wholesale price of other meat products (representing price averaging). When the function representing the equilibrium margin is substituted into the actual change in margin function the estimating form presented above can be derived.

yandle's OLS estimate of the pork margin yielded the following result:

$$\begin{aligned}
 Mp_t = & -3.721 + 0.081I_t - 0.105^W P_{pt} + 0.061Z_1 + 0.108 \Delta WP_{bt} \\
 & \quad .(0.042) \quad (0.081) \quad (0.267) \quad (0.100) \\
 & + 0.019\Delta^W P_{mt} - 0.633\Delta^W P_{pt} + 0.68IM_{pt-1} \\
 & \quad (0.086) \quad (0.079) \quad (0.099)
 \end{aligned}$$

R = 0.898, K = 1.816, figures in brackets are standard errors

K = Van Neuman Ratio

These results indicated that, for pork, only price levelling tended to be important as only the change in pork's own wholesale price was shown as being significantly different from zero. Neither price averaging or price control had had a significant influence on pork margins over the period (i.e. the parameters representing the influence of the change in wholesale prices of other meats and the price control dummy variable are all not significantly different from zero). The parameter representing the influence of the wholesale pork price has the wrong sign (although it is probably not significantly different from zero). This indicates that if retailers use proportionate mark-ups at all, these mark-ups are negative.

The parameter associated with the lagged dependent variable is very large indicating that:

"immediate adjustments are small to any changes in market forces ... suggesting that the meat retailer prefers to adjust slowly to the new market situation, perhaps so his customers will not notice."¹²

12. Ibid, p.246.

The size of this parameter is surprising and requires considerable justification. It implies a very slow adjustment to changes in "market forces" even after the effects of averaging and levelling have been separately identified. This implies either that some other price smoothing policy has been adopted by retailers (which is likely to be reflected in the $\Delta^w P_{pt}$ coefficient anyway), or that extreme inertia exists in the marketing system, or that this parameter estimate is biased. Given the relative importance of any behavioural or institutional characteristic required to produce this degree of market inertia it would be surprising if Yandle has overlooked it in his otherwise very detailed study of the New Zealand meat market. On the other hand, unless there are sharp movements in the pork margin series, the lagged dependent variable is likely to "explain" a considerable amount of the variation in the dependent variable. It is also probable that the use of OLS would produce biased estimates (because of simultaneous equation bias). Although it is difficult to form a judgement on the evidence presented, it appears quite possible that Yandle has over-estimated the size of the lagged dependent variables' coefficient. This conclusion is reinforced by the lack of a sufficient a priori explanation for the size of this coefficient.

Yandle's OLS estimate of the 'bacon and ham' margin equation yielded:¹³

$$M_{Ht} = -7.04 + 0.12I_t + 0.03W_{pHt} + 0.098\Delta^w P_{Ht} + 0.781M_{t-1}$$

(0.05) (0.05) (0.05)

$$R^2 = 0.88, K = 2.19$$

These results are not discussed in detail by Yandle. The current wholesale price is, again, non-significant implying

13. Ibid, p.260

no proportional mark-up behaviour. The positive and significant value attached to the change in retail price parameter is particularly worrying and implies de-stabilising pricing policies rather than price levelling. Like the pork results, these results suggest a very slow adjustment to equilibrium.

Neither of Yandle's results support a proportionate mark-up hypothesis (both equations have insignificant parameters associated with the current wholesale price of the particular product). His equations give a mixed result in terms of the relationship between retailers pricing policies and retail price stability. The pork equation indicates that retailers apply some stabilising pricing policies to pork (and indicates that price averaging is likely to be more important than margin levelling although the two policies are not clearly distinguishable). However, the bacon and ham equation indicates that retailers pricing policies may actually be de-stabilising. Yandle's results also support the hypothesis that adjustment lags are extremely long without offering good a priori evidence supporting this hypothesis. Finally, Yandle's estimation technique is likely to have biased the results. His own re-estimation of the pork margin equation using 2SLS yielded considerably larger parameters, and resulted in some parameters changing sign (however Yandle rejected the 2SLS results as unsatisfactory).

Although the Griffith study examines the Sydney meat market it does provide a useful framework for analysing marketing margins. Griffith estimates both wholesale and retail marketing margins for beef, lamb, mutton and pork using 42 monthly observations over the period January 1971 to June 1974. His specification for wholesale and retail pork margins were:

$$MWp = a_0 - a_1PAp + a_2CWp + a_3LPAP - a_4Tt - a_5MWL$$

$$MRp = b_0 - b_1PWp + b_2CR + b_3MRm$$

where:

- MWP, MR_p = wholesale and retail margin on pork respectively
- PA_p, LPA_p = current and lagged auction carcass price for pork
- CW, CR = wholesale and retail marketing cost index (wages and slaughtering fees)
- MW_L, MR_M = wholesale margin on lamb and retail margin on mutton
- T_t = total monthly throughput of all meat at wholesale

With respect to wholesalers behaviour Griffith found that:

"...wholesale margins are negatively related to current auction prices and positively related to past auction prices. This result suggests short run price levelling with longer term adjustment of wholesale margins to trends in auction prices ... Significant instances of price averaging exist in the beef, lamb and pork wholesale equations (MW_L is negatively related to MW_p)... wholesale costs have a small positive influence on wholesale margins of both beef and pork ... The expected negative relationships between throughput and wholesale margins occurred in the beef, lamb and pork equations."¹⁴

The results for retail pork margins were less compelling. Although the retail margin is negatively related to the current wholesale price it is not positively associated with the lagged wholesale price and the size of coefficient b_3 is not consistent with price averaging. It would appear from these results that, although the retail margin is positively related to retail marketing costs, Griffith was unable to distinguish consistent price averaging or levelling behaviour or a consistent turnover effect for pork at the retail level.

Both of Griffith's equations include a constant term as well as variables that measure marketing costs which indicates that a mixture of fixed and proportionate mark-ups is hypothesised. However, unlike Yandle, Griffith does not believe that proportionate mark-ups are related to current carcass costs

(i.e. the current auction and wholesale cost parameters are expected to have negative coefficients (representing price levelling behaviour)). Proportionate mark-ups are related to the purchase price of meat (the coefficient on the lagged cost is positive) but modified by levelling behaviour within any one month. Griffith also uses the margins applying to other meats (rather than the change in the wholesale price of these meats) to represent price averaging. This specification is superior to Yandle's because traders act to average margins over all meats and therefore it is the influence of other meat margins rather than the influence of changes in the wholesale price of other meats that is important. Finally, despite the fact that he is attempting to explain monthly rather than quarterly movements in margins, Griffith does not use a partial adjustment formulation. This (implicitly) assumes that, apart from the influence of price averaging, firms fully adjust to their equilibrium values within one month. This is in sharp contrast to Yandle's assertion that, in New Zealand, it would take nearly two years for a 95 percent adjustment to equilibrium in pork margins.¹⁵

6.4 Specification and Estimation of the Margin Equations Used in the New Zealand Pig-Meat Model

The general specification of the margin equation used in this study has similarities to those employed by both Yandle and Griffith. Margins are assumed to be influenced by a mixture of constant and proportionate mark-ups with the final impact of these mark-ups being modified by traders own stabilising pricing behaviour and government price regulation.

Lack of data precludes the separate identification of wholesale and retail pig-meat margins and the influence of other meat margins on the margins applied to pig-meat. Inability to separately identify the impact of margin averaging may not

15. C. A. Yandle, op cit, p.247

be particularly important. The work of both Yandle and Griffith suggests that margin averaging does not have a very significant effect on the formation of margins on pig-meat. Given the data available, it was decided to reflect all of the stabilising pricing behaviour of traders in one variable; the 'change in the farm price' of either porkers or baconers. This variable was assumed to be negatively related to margins (i.e. traders are hypothesised to absorb some of the change in farm prices into their margins).

The margins equations were then specified as:

$$DMP = f'(DFPP, CHFP, TOTPUT, DJBUT, TIME, COT, COT_2, D_2, D_3, D_4)$$

$$DMB = f''(DFPB, CHFPB, TOTPUT, DJBUT, TIME, FZN, COT_1, COT_2, D_2, D_3, D_4)$$

where:

- DMP, DMB = Real farm-to-retail margin on fresh and cured products respectively (c/kg)
- DFPP, DFPB = Real volume weighted sum of North and South Island farm prices of porkers and baconers respectively (c/kg).
- CHFP, CHFPB = The change in DFPP and DFPB respectively
- TOTPUT = Total consumption of beef, sheepmeat and pig-meat (a proxy for total meat throughput of the domestic marketing system).
- DJBUT = Real Journeyman's butchers wages (award wage)
- TIME = Dummy variable for time (fourth quarter 1968 = 1)
- FZN = Dummy variable for the three different periods when a price freeze on bacon and ham was in force (i.e. takes the value of unity in the fourth quarter 1970, the first quarter 1972, and the third quarter 1976 to the second quarter 1977 inclusive).
- COT₁ = Dummy variable for first period of control on both fresh and cured product margins (i.e. takes the value of unity from the first quarter 1971 to the first quarter 1972 inclusive).
- COT₂ = Dummy variable for second period of margins control (i.e. from the second quarter 1972 to the first quarter 1979 inclusive).
- D₂, D₃, D₄ = Seasonal dummies for the second, third and fourth quarters respectively.

Margins are assumed to have both a fixed and proportional component. Proportional mark-ups are assumed to be set proportional to farm prices (the parameter for the variables in both equations should be positive). The farm price coefficient will reflect a wastage factor as well as a factor reflecting proportional mark-up on cost. The farm price reflects the price paid to the farmer for each kilogram of slaughtered pig-meat he supplies. However, the retail price reflects the price paid by the consumer for each kilogram of pig-meat purchased from the retailer. Given that about only 80 percent of the carcass is recoverable as saleable cuts,¹⁶ there will be a direct (proportional) relationship between the margin and the farm price.¹⁷

This mark-up behaviour is expected to be modified by traders attempts to stabilise their output price and by a turnover effect.¹⁸ As already noted, the combined effects of all attempts by traders to stabilise their output prices is reflected in the influence of the 'change in farm price' variable which is assumed to have a negative parameter. With regard to turnover, there is some doubt about whether the turnover of the specific product or of all products handled by traders in the marketing system should be used as an explanatory variable.¹⁹ However, if traders are able

16. D. J. Fyfe, "How to Price Meat Cuts", Meat Marketing, Winter 1974 pp 8-10, 26-30 (p.29).

17. At 80% recovery the true cost to the butcher = $\frac{1}{0.8}$ farm price.
The butcher will add his margin to cost so that, with a 20% mark-up:

$$\begin{aligned}\text{Margin} &= 0.2 * \text{cost where cost} = 1.25 * \\ &= 0.2 * (1.25 * \text{farm price}) \\ &= 0.25 * \text{farm price} - (0.2 = \text{mark-up}; 0.05 = \text{wastage})\end{aligned}$$

18. It should be noted that these policies act to make retail prices more stable than farm prices. If we had assumed that demand was pre-determined and farm prices derived from retail prices (rather than visa versa) then these policies would actually be de-stabilising (i.e. would de-stabilise farm prices).

19. G. R. Griffith, op cit, p.229

to spread their fixed costs over all types of product then it seems reasonable to use the turnover of all meats as an explanatory variable. This variable will be less applicable to cured products (where specific curing plant is needed) than fresh pork. Both cured pig-meat and total meat turnover were used in alternative specifications of the cured products equation and total turnover was found to be a more significant determinant of the level of margin on cured products.

Dummy variables are used to reflect intercept changes in response to retail price control (FZN) and control on margins (COT₁ and COT₂). The assumption is that the effect of these controls can be adequately represented by intercept changes (i.e. reductions in the average level of margin per kilogram over the controlled period). This could be a simplification of actual behaviour; controls may influence the relationship between the dependent and independent variables (i.e. change the value of parameters other than the intercept in the equations). However, price control has been in force, in one form or another, for prolonged periods since the war and may simply act to lower margins without having a significant effect on traders' pricing responses. Separating the periods of retail price control from periods of margin control allows us to identify the separate influences of these two different types of control on margins. Separating the period of margin control into two periods also allows us to identify the separate impact of the Price Justification Scheme and the Stabilisation of Prices Regulations.

A dummy variable which allows constant adjustment of the intercept through time was also introduced into the equations. This variable could reflect two types of changes; systematic increases in the quantity or quality of marketing services performed and/or a systematic increase in real costs not otherwise identified in the equation. The Committee of Inquiry

into the distribution of meat, fish, fruit and vegetables noted significant improvements in both the quality and quantity of marketing services offered by retailers of fresh meat in the ten years prior to 1973.²⁰ Their report noted improvements in hygiene and in shopping conditions as well as improvements in the presentation of fresh meat.

Finally, seasonal dummies are included to reflect seasonal changes in costs not associated with costs identified elsewhere (i.e. either explicitly in the butchers wage variable or implicitly in the deflation of all variables). Storage costs are likely to be the most important of these other seasonal costs and for that reason the seasonal coefficients in the cured products equation are likely to be far more significant than those in the fresh pork equation.

It has been assumed that, apart from specific policies to stabilise their prices, traders are both willing and able to fully adjust their margins to changing conditions within any single quarter. To maintain that a longer adjustment lag is required implies considerable inertia in the domestic marketing system. It is difficult to reconcile the degree of inertia implied by long adjustment lags with the competitive nature of the trade. At this stage there are no good grounds for believing that inertia in the pricing decisions of meat traders is sufficient to justify the inclusion of a partial adjustment mechanism into the margin equations.

The two margin equations were estimated using quarterly observations for the period 1970 (second quarter) to 1979 (second quarter) and 2SPC. Unfortunately these initial estimates suffered from serious positive autocorrelation. The Durbin-Watson statistics were 0.80 and 0.87 for cured and fresh pork margins respectively which indicated positive

20. See pages 49 and 50 of the Report.

autocorrelation at the 5 percent level of significance. Therefore the equations were re-estimated using the Cochrane-Orcutt Iterative technique to remove this autocorrelation. The parameters associated with both the butchers wage (DJBUT) and TIME variables were highly insignificant in the cured product equation so these two variables were rejected and this equation was re-estimated with the new (restricted) set of explanatory variables. This procedure yielded the following results:

$$\begin{aligned}
 \text{DMP} = & 89.32 + 0.382 \text{ DFPP} - 0.173 \text{ CHFPP} - 0.175 \text{ TOTPUT} \\
 & (43.5) \quad (0.128) \quad (0.16) \quad (0.178) \\
 & + 0.347 \text{ DJBUT} + 0.625 \text{ TIME} - 3.44 \text{ COT}_1 - 3.95 \text{ COT}_2 \\
 & (0.275) \quad (0.337) \quad (5.97) \quad (4.81) \\
 & + 0.92 \text{ D}_2 - 1.75 \text{ D}_3 - 1.36 \text{ D}_4 \\
 & (2.32) \quad (2.21) \quad (1.97)
 \end{aligned}$$

$$R^2 = 0.828, \text{DW} = 1.73, \hat{p} = 0.68 \quad \text{standard errors in} \\
 (0.12) \quad \text{brackets}$$

$$\begin{aligned}
 \text{DMB} = & 355.62 + 0.766 \text{ DFPPB} - 0.341 \text{ CHFPPB} - 0.287 \text{ TOTPUT} \\
 & (39.50) \quad (0.231) \quad (0.218) \quad (0.261) \\
 & - 5.33 \text{ FZN} - 15.56 \text{ COT}_1 - 21.71 \text{ COT}_2 - 4.5 \text{ D}_2 \\
 & (4.2) \quad (8.1) \quad (7.95) \quad (2.9) \\
 & - 7.28 \text{ D}_3 - 6.51 \text{ D}_4 \\
 & (3.22) \quad (2.38)
 \end{aligned}$$

$$R^2 = 0.936, \text{DW} = 1.88, \hat{p} = 0.91, \quad \text{standard errors in} \\
 (0.07) \quad \text{brackets}$$

The value for \hat{p} is both high and significant in both equations. In the cured products equation \hat{p} is close to unity which indicates that this transformed equation is approaching a first difference form.

6.5 Evaluation of the Parameter Estimates

All of the parameters in both equations have the expected sign; the margin is positively related to farm price, butchers wages, and time, and negatively related to the change in farm price, throughput and price control dummy variables. Both equations also indicate a mixture between fixed and proportionate mark-ups in price setting behaviour, and give some support to the hypothesis that traders will act to stabilise retail prices (presumably by averaging movements in farm prices (and/or levelling margins) between quarters).²¹

The coefficients of determination for both equations are reported along with the equations (above) and indicate that 83 percent and 94 percent of the total variation in the margin per kilogram for fresh pork and cured pig-meat respectively is explained by the changes in the explanatory variables.

The significance of proportionate mark-ups in determining margins on fresh pork is illustrated by the farm price parameter in this equation. As already noted this parameter includes the influences of the carcass recovery rate as well as proportional mark-up pricing. With an 80 percent recovery rate the coefficient would be reduced to $(0.382/1.25 =) 0.3$ if it were to reflect proportional mark-up only. Thus at average prices the combined wholesale and retail mark-up has a proportionate component equivalent to 30 percent of recoverable carcass cost (or 38 percent of farm prices).

²¹ Although (if margin levelling is a significant determinant of pork margins) levelling will not necessarily act to reduce the impact of a change in farm prices on margins it will have a tendency to do so unless all farm meat prices are strongly correlated. Therefore we cannot exclude the possibility that the 'change in farm price' variable is capturing some margin levelling behaviour.

The combined influence of traders averaging and levelling policies on pork margins is relatively weak (the 'change in farm price' variable has a parameter that is only significant at the 30 percent level). The relative size of the 'farm price' and 'change in farm price' parameters indicates that the margin will always move in the same direction as farm prices (*ceteris paribus*). However, the combined influence of averaging and levelling acts to reduce a change in margins associated with a given change in farm price by $(0.173/0.382 =)$ 45 percent. The combined influence of a constant mark-up and the averaging and levelling pricing policies acts to reduce the impact of a given change in farm prices on retail prices (a 1 percent charge in farm prices results in a 0.49 percent increase in retail prices at average price levels).²² An examination of the retail and farm price series for fresh pork indicates that although the standard deviation of retail prices is larger than farm prices (i.e. 27.4 and 19.4 respectively), the proportionate variation in farm prices (i.e. the standard deviation divided by the mean) is considerably greater than that in retail prices (i.e. 9.2 percent and 15.7 percent respectively).

The influence of throughput on margins is also very weak (the standard error exceeds the parameter estimate) although negative. Butchers' wages are, as expected, positively

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22. For example, at average prices the farm price is 123c/kg, the margin is 176c/kg and the retail price 299c/kg. A 10 percent increase in farm prices will have the following effect:

$$\text{Change in farm price} = 123\text{c} * 10\% = 12.3\text{c}$$

$$\text{Change in margin}$$

$$\text{Change in margin} = 0.382 * \frac{(123 * 1.1) - 123}{4.69} - 0.173 * \frac{(123 * 1.1) - 123}{2.13} = 2.56\text{c}$$

$$\begin{aligned} \text{Change in Retail Price} &= \text{Change in Farm Price} + \text{Change in Margin} \\ &= 12.3\text{c} + 2.56\text{c} \\ &= 14.86\text{c or } 4.9\% \end{aligned}$$

A 10 percent increase in farm price results in only a 4.9 percent increase in retail price. Without the impact of averaging and levelling policies retail prices would increase by 5.7 percent.

correlated with pork margins although the standard error of this parameter estimate is also large. The simple correlation coefficient between butchers wages and the farm price of pork is 0.64 which indicates that multicollinearity may be affecting the standard error of this variable. The TIME variable parameter is significantly different from zero at the 10 percent level which indicates that some reasonably consistent increase in either the quality or quantity of marketing services or in an unidentified real marketing cost has occurred. The seasonal dummies are all insignificant and could reasonably be excluded from this equation when the model is re-estimated. It is also interesting to note that the parameters for the two price control dummy variables are also insignificant which indicates that Government regulation of fresh pork margins has not reduced these margins below what they otherwise would have been. Given the practical difficulties inherent in trying to control margins on fresh meat this result is not surprising.

The value for rho estimated for the cured products margin equation is extremely high and, as noted, means that this equation closely approaches a first difference form. This complicates the interpretation of some of the parameters.

The farm price parameter in the cured products equation is positive, significant and considerably larger than the comparable parameter in the fresh pork equation. This parameter estimate indicates that (using an 80 percent carcass recovery rate) the proportional mark-up on cured products is equivalent to 61 percent of recoverable carcass costs.

The combined influence of averaging and levelling is, again, relatively weak. The 'change in farm price' parameter is only significant at the 20 percent level and its absolute value is smaller than the farm price parameter which indicates that the bacon margin will always move in the same direction

as farm prices (*ceteris paribus*). However, the combined influence of averaging and levelling is to reduce the change in margin associated with a given change in farm price by $(0.341/0.766 =)$ 44.5 percent (i.e. is virtually exactly the same proportion as in the fresh pork equation). Again the combined influence of a constant mark-up and averaging and levelling pricing policies acts to reduce the impact of a given charge in farm prices on retail prices (in this case a 1 percent charge in farm prices results in only a 0.36 percent change in retail prices at average price levels). A comparison of the variation in the retail and farm price series for cured pig-meat indicates that, although the standard deviation of retail prices is higher than that for farm prices (i.e. 41.8 and 21.1 respectively), the proportionate variation in farm prices is virtually double that in retail prices (i.e. 7.8 percent and 15.2 percent respectively).

The influence of throughput on the margin is very weak although negative (the parameter is significantly different from zero only at the 30 percent level). The margin will be reduced by only 0.06 percent for every 1 percent increase in total meat throughput. However, unlike fresh pork margins, price control appears to have been effective in lowering margins on cured pig-meat.

The price freeze parameter is only significant at the 20 percent level, however, for five of the six quarters for which a freeze on retail prices of bacon and ham was in force, margins were also controlled. Therefore this parameter indicates that there is some evidence to support the hypothesis that the freezing of retail prices of bacon and ham has an effect on margins additional to control on margins of these products. However the interpretation of this parameter is complicated by the Cochrane-Orcutt transformation; the variables include a -0.91 observation

in the quarter following the lifting of controls (i.e. $-5.3 \cdot FZN$ has been transformed into $-5.3 \cdot (FZN_t - 0.91 \cdot FZN_{t-1})$). Therefore the parameter is capturing the negative influence of price control on margins plus any immediate positive influence that the lifting of price control may have had on margins.

The interpretation of the margin control parameters (COT_1 and COT_2) is likewise confused. In the untransformed state the interpretation would be that the regulation of margins has reduced the level of margin on cured pig-meat by an average of 15.5c/kg (3.9 percent), during the enforcement of the Price Justification Scheme and 21.7c/kg (5.4 percent) during the enforcement of the Stabilisation of Prices Regulations with periods of price freeze depressing margins by another 5c/kg. Because of the Cochrane-Orcutt transformation (and because of the plausibility of traders attempting to increase margins immediately after controls are relaxed), these parameter estimates are affected by the response of traders in the period immediately following the removal of price control. However, it would be extremely difficult to maintain that price controls have had no restraining influence on cured pig-meat margins.

Finally, the seasonal dummy variable parameters are all significantly different from zero (although the second quarter dummy is only significant at the 20 percent level). Significant season fluctuations in cured pig-meat margins reflect seasonal fluctuations in costs (predominantly storage costs). After allowing for the Cochrane-Orcutt transformation, the relevant seasonal intercepts are: first quarter (constant +5.8), second quarter (constant -4.5), third quarter (constant +3.2), fourth quarter (constant).²³

From the information above it is possible, and useful, to derive the farm price elasticity of demand for fresh and

23. For example, the fourth quarter value can be calculated as $\alpha_{1D4} - \rho \alpha_{2D3} = -6.5 - 0.91 \cdot -7.2 = -6.5 + 6.5 = 0$.

cured pig-meat (i.e. the responsiveness of demand to changes in farm prices). Given that only farm prices are under the direct influence of the Pork Marketing Board, the farm price elasticity of demand is of considerable interest to industry policy-makers. Using average prices and quantities and the retail price elasticities of demand in Table 5-6 the farm price elasticity of demand for fresh pork is -0.75 and the farm price elasticity of demand for cured pig-meat is -0.187.²⁴ These are both short run elasticities (i.e. moderated by the effects of averaging and levelling pricing policies). The long run elasticities (i.e. the response of consumption to a sustained increase in farm prices) will be more elastic than these short run elasticities.

Finally, the stability of the parameter estimates for both equations was tested by re-estimating the equations using a smaller number of observations. The procedure used in testing the stability of the parameter estimates in the demand equations was used again; five observations were dropped from the end of the sample period and the equations re-estimated using 31 rather than the original 36 observations. The charges

24. These results were derived as follows:

- (a) Fresh Pork - we have already noted that a 1% increase in farm prices will result in a 0.49% increase in retail prices. Using the retail price elasticity of demand of -1.54, this 0.49% increase in retail prices will result in a 0.75% decrease in per capita consumption. The farm price elasticity of demand for pork is therefore $-0.75/1.00 = -0.75$.
- (b) Cured Pig-Meat - a 1% increase in farm prices will result in a 0.36% increase in retail prices. Using the retail price elasticity of demand of -0.52, this 0.36% increase in retail prices will result in a 0.187% decrease in per capita consumption. The farm price elasticity of demand for cured pig-meat is therefore $-0.187/1.00 = -0.187$.

These results ignore the aggravating effect that the decline in consumption (and therefore throughput) would have on margins (and therefore retail prices). As the parameters in both equations for throughput are small (as are the corresponding elasticities), and as pig-meat is only a small proportion of total consumption, this simultaneity will only have a minor impact on the farm price elasticity of demand.

in coefficients were then tested for significance using an F statistic and the results presented in Table 6-1. Because the computed F statistic is less than the critical value (at the 5 percent level significance) we accept that the structural coefficients in both equations are stable (i.e. do not change as the sample size decreases from 36 to 31).

Table 6-1

Testing the Structural Stability of
the Pig-Meat Margin Equations

n	Fresh Pork		Cured Pig-meat	
	36	31	36	31
Constant	89.3	76.34	355.6	372.5
Porker Price	0.382	0.366	-	-
Change in Porker Price	-0.173	-0.198	-	-
Baconer Price	-	-	0.766	0.818
Change in Baconer Price	-	-	-0.341	-0.356
Throughput	-0.175	-0.144	-0.287	-0.296
Butchers Wages	0.347	0.417	-	-
Time	0.625	0.480	-	-
Price Freeze Dummy	-	-	-5.33	-7.49
Price Control 1	-3.44	0.64	-15.56	-22.38
Price Control 2	-3.95	3.56	-21.71	-34.09
D ₂	0.92	0.78	-4.5	-4.8
D ₃	-1.76	-1.76	-7.28	-8.5
D ₄	-1.36	-1.18	-6.51	-7.6
e ²	714.05	680.21	1,824.27	1,669.27
F*	0.199		0.383	
p	0.68	0.68	0.91	0.92

* The critical value for F at 5% level is 2.71.

An examination of Table 6-1 indicates that none of the original individual significant parameters have changed a great deal. The butchers wage parameter also appears to be reasonably stable which does not support the conclusion that multicollinearity has affected the standard error of this estimate. The price control parameters in the fresh pork equation have changed signs but still remain insignificantly different from zero. The price control parameters in the cured pig-meat equation have increased in absolute value. This supports the earlier conclusion that the influence of price control on pig-meat margins has only been significant in the case of cured products.

6.6 Conclusion

This chapter has discussed the specification, estimation and evaluation of the margins equations used in the New Zealand Pig-Meat Model. A number of important conclusions can be drawn from an analysis of pig-meat margins about the pricing behaviour of processors, wholesalers and retailers and the effectiveness of price control:

- (a) The combined mark-up behaviour of all traders is best represented by a mixture of fixed per kilogram mark-ups and mark-ups that are proportional to costs (predominantly the farm price of carcass meat);
- (b) Some evidence exists to indicate that this behaviour is modified by traders own attempts to stabilise their output price between successive quarters and by the influence of throughput on margins. However, this evidence is not very strong and indicates that margins will continue to move in the same direction as farm prices despite traders use of 'stabilising'

pricing policy. However the combined effects of constant mark-ups and stabilising pricing policies do act to moderate the effect of changes in farm prices on retail prices. The farm price elasticity of demand for both classes of pig-meat is considerably more inelastic than the retail price elasticity of demand in the short run;

- (c) The evidence on the effect of price control is reasonably strong and indicates that, although government regulation of prices and margins has reduced margins on cured pig-meat it has had no significant effect on fresh pork margins. This latter conclusion is also supported by Yandle's earlier work on fresh pork margins.

CHAPTER SEVEN

THE FARM PRICE EQUATIONS : SPECIFICATION, ESTIMATION AND EVALUATION

7.1 Introduction

This chapter discusses the specification, estimation and evaluation of the four equations used to describe movements in the farm price of porker and baconer pigs in both the North and South Island. Farm prices act to balance supply and demand in the model. In the cured product "market" processors and wholesalers adjust farm prices in an effort to maintain stocks at a desired level (i.e. to reduce, or eliminate, either excess supply or demand). The lack of fresh pork stock means that the supply and demand of fresh pork are brought into balance by changes in farm prices.

The chapter is divided into three main sections. The first section describes a generalised specification of the farm price relationship based on the hypothesised pricing behaviour of processors and wholesalers. This specification is consistent with the generalised specification of the entire model discussed in Chapter Four. The second section discusses the specification and estimation of each of the four equations used in the New Zealand pig-meat model. When considering the disaggregated "market" the generalised specification discussed in the first section has to be modified to reflect special characteristics of the individual "markets" (especially the close relationship between the four farm prices). Finally, the parameter estimates for each equation are evaluated and the stability of these estimates discussed.

7.2 Generalised Specification of the Farm Price Relationship

7.2.1 Price Formation in the Cured Pig-meat "Market"

Labys describes a general commodity model which can be used to reflect competitive behaviour in which consumption and production are a function of current and lagged prices and prices are a function of the change in stocks which are determined by subtracting consumption from production.¹ He notes that different forms of price relationships can be postulated for different assumptions about the price elasticity of response of production and consumption and the length of data interval used relative to the lags in the market.² Price determination can be explained by stock changes if the data interval is short relative to the lags and stocks vary considerably. The generalised model structure developed in Chapter Four for the cured products market is an example of this type of price determination where the underlying price structure reflects a flow adjustment (rather than a stock adjustment) process.³ In this type of process, excess demand or supply leads to an increase or decrease in prices which tends to reduce the original excess demand or supply. The amount of excess demand or supply is reflected in the change in stocks. Therefore, the price equation reflects the behaviour of processors and wholesalers who adjust farm prices in an effort to change stocks to some desired level (i.e. to eliminate excess supply or demand).

Although the price formation hypothesis in this "general model" is useful in describing the farm price formation

1. W. C. Labys', Dynamic Commodity Models; Specification, Estimation and Simulation, p.93

2. Ibid, p.93

3. The flow adjustment process suggests that prices are a function of the change in stocks whereas the stock adjustment process expresses prices as a function of stock levels.

process for cured pig-meat it is a considerable oversimplification of processors and wholesalers pricing behaviour. Firstly, the actual change in stocks will not be a good measure of excess supply or demand because these changes will include an intended as well as unintended component. If processors and wholesalers desire to hold more stock (e.g. in response to some exogenous factor) the corresponding increase in stock levels is a result of an increase in demand (i.e. processors demand for stocks), it does not reflect excess supply. It is only the unintentional increase (decrease) in stock levels that reflects excess supply (demand) and results in a decrease (increase) in farm prices. Intended changes in stock levels may have the opposite influence on prices because they represent an increase or decrease in demand respectively. Therefore the appropriate variable to include as an explanatory variable in the price equation (i.e. the variable that reflects excess supply or demand) is the unintended change in stocks rather than the actual change in stocks. This variable is approximated by Meadows in his general model of commodity production cycles by the ratio of actual to desired "inventory coverage" (i.e. the number of months present inventory (stock) levels can support expected consumption rates.)⁴ It is only when the actual coverage deviates from "the average value of coverage provided by inventory over the course of one hog cycle"⁵ (=desired coverage) that a price response will be initiated.

The second major change required to the general model described by Labys is to include variables that reflect the expectations behaviour of processors and wholesalers. Fuller and Ladd note that:

"In their study of meat inventories, Tolley and Harrell concluded that packers were fairly

4. D. L. Meadows, Dynamics of Commodity Production Cycles, Wright-Allen Press, Inc., Massachusetts, 1970, p.43.

5. Ibid, p.43.

successful in predicting changes in supply but unsuccessful in forecasting shifts in demand." ⁶

Thus, we could expect processors and wholesalers to anticipate the trend in the supply of pig carcasses and adjust prices to avoid a costly unintended stock build-up. If these buyers could correctly anticipate movements in both the supply of live pigs and the demand for processed pig-meat (and therefore adjust prices to avoid unintended stock changes), price would merely be a function of these anticipated supplies and demands. However it is unlikely that buyers will correctly anticipate movements in supply and even less likely that they will correctly anticipate changes in demand. These errors will show up in unintended stock changes which will result in further price modification. If Tolley and Harrell's conclusions are applicable to New Zealand then variables that reflect buyers anticipation of supply movements will be very important in determining farm prices. Unintended stock changes would then be dominated by unanticipated demand factors.

Finally, the general model needs to be modified to take into account any effects that exogenous shocks to margins may have on the farm price. In Chapter Six the margin equations were formulated using a modified "cost-plus" specification of traders' pricing behaviour. This implicitly assumes that any effect that changes in margins will have on farm prices will be indirect (e.g. by changing retail prices, consumption and stocks). This is probably a realistic assumption. However, it is possible to include margins as an explanatory variable in the farm price equations to test whether or not the level of margin has a direct effect on farm prices.

6. W. A. Fuller and G. W. Ladd, "Quarterly Model of the Beef and Pork Economy", Journal of Farm Economics, Volume 43, 1961, p.806 quoting a paper by G. S. Tolley and C. Harrell, Inventories in the Meat Packing Industry, Agr. Ec. Inf. Ser. 58, N. C. State Coll., December 1957, p.45.

7.2.2 Price Formation in the Fresh Pork "Market"

As noted in Chapter Four, the lack of fresh pork stocks precludes the adoption of a similar generalised model to explain price formation in the fresh pork market. Unfortunately, lack of adequately disaggregated data also precludes the adoption of a simple equilibrium model where an explicit price equation is not required. However, in the restricted fresh pork market model described in Chapter Four prices play the dominant role in finding the supply-demand balance.

The farm price for porkers has been assumed to be a function of buyers' anticipated trend level of porker production modified by the influence of baconer prices and porker margins. Given the close substitutability between baconer and porker production a strong link between the farm price for bacon and pork weight pigs would be expected. This formulation places virtually all of the emphasis on supply factors in determining farm price levels. As noted in Chapter Four this problem can be limited by the introduction of constraints on the level (or growth) of fresh pork exports. However, it is possible that the margin and seasonal dummy variables will act as a proxy for the (excluded) demand side effects. This should be borne in mind when interpreting the results.

A detailed description of the specification of the farm price equations is given in the next section.

7.3 Specification and Estimation of the Farm Price Equations Used in the New Zealand Pig-Meat Model

This section discusses the specification of separate farm price equations for baconer and porker pigs for both North and South Islands given the generalised specification discussed above. Because of the close substitutability between the production of pork and bacon weight pigs movements in these disaggregated prices are likely to be

inter-related. For example, if the North Island farm price for bacon weight pigs increases, they will tend to force up the price of pork weight pigs in the North Island and both pork and bacon weight pigs in the South Island. Because of the anticipatory behaviour of buyers, this inter-relationship between the various farm prices may not be adequately represented by volume movements. For example the buyers of pork weight pigs in the North Island will, to a certain extent, increase their prices to avoid a diversion of potential pork weight pigs onto the bacon market rather than adjusting in response to such a diversion. Therefore, a number of these prices will be directly related rather than related indirectly (through volume changes) and will have to appear as both dependent and explanatory variables in this set of equations.

There is relatively widespread acceptance that the farm price for baconers is the critical price in determining other farm prices for pigs:

"The prices for all classes of pigs revolve around the bacon schedule, since this is the maximum profitable slaughter weight."⁷

Therefore the farm price for baconer pigs in each island was used as an explanatory variable in that island's porker price equation. There also needs to be a direct link between North and South Island prices for baconers. Given the importance of North Island baconer production in total baconer production (i.e. in excess of 63 percent even in the 1979 season) it was decided to use the North Island baconer price as the linking variable. Therefore, the South Island baconer price appears as an explanatory variable in the South Island porker price equation, and the North Island baconer price appears as an explanatory variable in both the North Island porker price and South Island baconer price

7. Pork Industry Council, Pig Production and Management Manual, Present Industry Structure section, p.3.

equations. It should be noted that this structure does not preclude the effect of any one price change on any other indirectly (i.e. via volume changes). However, it does assumed that, in forming their expectations about the impact of close substitutes on price, pork wholesalers use the farm price of baconer pigs and South Island bacon processors use the North Island baconer price. Buyers in the largest single "market" (i.e. the North Island baconer "market") are assumed to ignore the influence of price changes in the smaller markets. These buyers are assumed to be influenced by the supply of pigs to their "market" and unintended change in national stock levels.

Stocks data was not available on a regional disaggregated basis which implies we have assumed that either movements in North and South Island stocks are highly correlated or that changes in South Island stocks effect North Island buyers. Because of this lack of disaggregation in the stocks variable, it was excluded from the South Island baconer "market". Given that the North Island baconer price has a direct effect on the South Island baconer price it was decided that omitting the aggregate stocks variable would cause less problems than including it. Therefore it is only the North Island farm price for baconers equation that closely conforms with the "general specification" outlined in section 7.2.1 above.

All of the farm price equations also needed to include a variable to account for the influence of the Pork Marketing Board's Basic Minimum Price scheme during the 18 month period in 1977/78 during which the basic minimum price was paid. A dummy variable (set equal to unity during the period of price support) was used to account for the average effect of the scheme on farm prices during the period in which farm prices were supported by Board intervention.

7.3.1 The Farm Price for Baconer Pigs in the North Island

The original specification of this equation was identical to the modified generalised specification discussed above.

$$DFPBN = f(PBN^*, \Delta S - \Delta S^*, BMP, DMB, D_2, D_3, D_4)$$

where:

DFPBN	= Real farm price of bacon weight pigs in the North Island (c/kg)
PBN*	= Buyers anticipated level of production (tonnes)
ΔS	= Actual change in stocks
ΔS^*	= Intended change in stocks
BMP	= Dummy representing period of price support
DMB	= Real farm to retail margin on cured products
D_i	= Seasonal dummy for quarter i ($i=2,3,4$)

Before an estimating form can be derived, PBN* and ΔS^* have to be defined in terms of observable variables.

The PBN* variable has to reflect buyers' anticipations of the level of production. Haas and Ezekiel note that United States hog buyers are likely to respond differently to what they perceive of as "temporary" and "trend" movements in supply.

"... during short periods when receipts (of live hogs) temporarily fell below the general average the competition to get a share of the business forced prices somewhat above the general trend, though not nearly so much as did an equal shortage in supply extending over a considerable period."⁸

Given that buyers are considerably better able to anticipate trend movements than actual movements, that the response to anticipated trend movements is likely to be more important than to temporary movements, and that all unanticipated movements are captured by change in unintended stocks, the PBN* variable was specified to reflect buyers' anticipation of the trend level of production. PBN* was therefore set equal to a four quarter moving average of production (i.e. $PBN_t^* = (PBN_{t-3} + PBN_{t-2} + PBN_{t-1} + PBN_t)/4$).

8. Haas, C. G. and Ezekiel, M. "Factors Affecting Hog Prices", United States Department of Agriculture Bulletin 1440, November 1926, pp 10-11.

This definition of PBN^* complicates the estimation of the $DFPBN$ equation. Firstly, the dummy variable $D20Q$ must be added to the equation to accommodate the influence of the grading classification change in 1973. Secondly, this change in grading classification will confuse the interpretation of PBN_t^* for the three quarters immediately following the grading classification change (i.e. these observations will be a mixture of the pre and post grading change periods). Therefore the estimation period should omit these three observations

The ΔS^* variable is a behavioural variable reflecting the intended change in stocks. Labys describes a number of models that have been used to explain stock holdings behaviour and notes the importance of transactions, precautionary and speculative motives for holding stock. In a relationship explaining the level of desired stocks he notes that:

"Precautionary demand is given in the form of (the constant term) implying that such demand to approximately constant over time; transactions demand is characterised by the consumption variable; and speculative demand is represented by the combined price expectations variable".⁹

The transactions demand is assumed to vary in direct proportion to output (in this case consumption), firms are assumed to hold these stocks to ensure continuity of production. In pig-meat processing losses incurred by having temporarily underutilised capacity are potentially important and, therefore, continuity of production is likely to be a significant motive for holding stock. Speculative demand implies that some firms will desire larger stocks when price rises are expected and vice versa. Apart from these three sources of demand for stocks it was assumed that stock levels were sensitive to the cost of holding stocks (which is approximated by the opportunity cost of having funds tied up in pig-meat stocks over the

9. W. C. Labys, op cit, p.75

quarter, (i.e. the three month secured deposit interest rate)).
Therefore:

$$\Delta S^* = a_0 + a_1 \text{CHFPBN}^* + b_2 \text{CHCON} - b_3 \text{CDINT}$$

where:

CHCON = change in consumption of cured
pig-meat
CDINT = change in the real interest rate
CHFPBN* = expected change in the real farm
price of baconers in the North
Island (which was assumed to be
equal to LICFBN; the actual
lagged change in farm price of
baconers in the North Island).

Finally, in order that $\Delta S - \Delta S^*$ represents unintended changes in stocks the intended seasonal variation in ΔS needs to be removed. Given the nature of the cured pig-meat trade, normal seasonal stock changes are likely to be a very important component of actual stock movements. However this seasonal fluctuation in stock levels represents changes in actual demand (i.e. intended stock changes) rather than changes in excess supply or demand and will therefore not trigger an inverse price response. These regular seasonal stock movements were removed by deseasonalising the 'change in stocks' series before including it in the regression.¹⁰

Substituting ΔS^* back into our original equation and adding D20Q we have:

10. This variable was deseasonalised by using the method of ratio of the series to a moving average (see the SAMAQ procedure in the Time Series Processor Users' Manual (Version 2.5 : Harvard), August 1978, pp B.11.1 - B.11.2). A method which allowed the seasonal pattern to change through time would have been superior and should be considered in model re-estimation.

$$\begin{aligned}
DFPBN &= a_1 - a_2 PBN^* - a_3 (\Delta S - \Delta S^*) + a_4 BMP - a_5 DMB + a_6 D20Q + \text{seasonal dummies} \\
&= a_1 - a_2 PBN^* - a_3 (\Delta S - (b_0 + b_1 L1CFBN + b_2 CHCON - b_3 CDINT)) + \dots \\
&= a_1 - a_2 PBN^* - a_3 \Delta S + a_3 b_0 + a_3 b_1 L1CFBN + a_3 b_2 CHCON - a_3 b_3 CDINT + \dots \\
&= (a_1 + a_3 b_0) - a_2 PBN^* - a_3 \Delta S + a_3 b_1 L1CFBN + a_3 b_2 CHCON - a_3 b_3 CDINT + \dots \\
&= c_1 - c_2 PBN^* - c_3 \Delta S + c_4 L1CFBN + c_5 CHCON - c_6 CDINT + c_7 BMP \\
&\quad - c_8 DMB + c_9 D20Q + c_{10} D_2 + c_{11} D_3 + c_{12} D_4
\end{aligned}$$

where:

$$PBN^* = (PBN_{t-3} + PBN_{t-2} + PBN_{t-1} + PBN_t) / 4$$

$$\Delta S = \text{deseasonalised change in stocks}$$

The signs indicated are those expected on a priori grounds.

This equation was estimated using quarterly observations for the period 1970 (second quarter) to 1979 (second quarter) with the observations for the fourth quarter 1973 to the second quarter 1974 inclusive excluded. The real cured product margin parameter was not significantly different from zero so the null hypothesis (that margins do not have a direct influence on farm prices) was accepted and the DMB variable removed from the estimating equation. The re-specified equation was re-estimated using 2SPC. Unfortunately the errors in this equation were autocorrelated (the Durbin-Watson = 0.9) therefore it was re-estimated using the Cochrane-Orcutt iterative technique to transform the equation and remove the autocorrelation. This procedure yielded the following results

$$\begin{aligned}
DFPBN &= 257.168 - 0.0284 PBN^* - 0.000058 \Delta S + 0.387 L1CFBN \\
&\quad (0.0132) \quad (0.00041) \quad (0.243) \\
&= -0.0181 CDINT + 0.0052 CHCON - 4.6 BMP + 42.11 D20Q \\
&\quad (0.015) \quad (0.0046) \quad (5.8) \quad (44.02) \\
&= -1.289 D_2 - 5.02 D_3 - 6.215 D_4 \\
&\quad (3.901) \quad (4.83) \quad (6.01)
\end{aligned}$$

$$R^2 = 0.938, \text{ DW (adjusted for the gap in observations)} = 1.54, \\ p = 0.945 (0.05), \text{ standard errors in brackets.}$$

7.3.2 The Farm Price for Baconer and Porker Pigs in the South Island and for Porker Pigs in the North Island

As already noted, because of the inter-relationship between farm prices, the specification of the other farm price equations in the model are highly modified forms of the generalised specification discussed above. The direct effect of the North Island baconer price on the South Island baconer price and of the baconer prices on the porker prices are modified by the supply of live pigs in the category under consideration, BMP price support; and the effect of exogenous changes in margins.

$$DFPBS = f'(PBS^*, DFPBN, DMB, BMP, D2OQ, D2, D3, D4)$$

$$DFPPS = f''(PPS^*, DFPBS, DMP, BMP, D2OQ, D2, D3, D4)$$

$$DFPPN = f'''(PPN^*, DFPBN, DMP, BMP, D2OQ, D2, D3, D4)$$

where:

DFPBS, DFPPS, DFPPN = Real farm price of baconers and porkers in the South Island and porkers in the North Island respectively (c/kg).

PBS*PPS*, PPN* = Buyers anticipated trend level of production of baconers in the South Island, and porkers in the North Island respectively (tonnes). Calculated as a four quarter moving average.

DMB, DMP = Real farm-to-retail margins for baconers and porkers respectively (c/kg).

BMP = Dummy variable representing period of price support.

Di = Seasonal dummy for quarter i (i = 2, 3, 4)

These equations were estimated using quarterly observations for the period 1970 (second quarter) to 1979 (second quarter) with the observations for the fourth quarter 1973 to the

second quarter 1974 inclusive excluded. Again, the real cured product margin parameter was not significantly different from zero and this variable removed from the DFPBS equation. The 2SPC estimates indicated that positive autocorrelation was a problem in both the South Island baconer equation (DFPBS) and the North Island porker equation (DFPPN) so these two equations were re-estimated using 2SPC(CORC). This procedure yielded the following results:

$$\begin{aligned} \text{DFPBS} = & 70.99 - 0.022\text{PBS}^* + 0.899\text{DFPBN} - 2.33\text{BMP} \\ & (0.013) \quad (0.123) \quad (4.78) \\ & - 40.59\text{D2OQ} - 5.22\text{D}_2 - 1.41\text{D}_3 + 3.38\text{D}_4 \\ & (15.48) \quad (2.55) \quad (2.89) \quad (2.44) \end{aligned}$$

$$\begin{aligned} R^2 &= 0.935, \text{ DW (adjusted for the gap in observations)}=1.82, \\ \hat{p} &= 0.32 \\ & (0.16) \end{aligned}$$

$$\begin{aligned} \text{DFPPN} = & 125.32 - 0.0194\text{PPN}^* + 0.578\text{DFPBN} - 0.2489\text{DMP} \\ & (0.0144) \quad (0.0144) \quad (0.177) \quad (0.290) \\ & + 2.55\text{BMP} + 11.23\text{D2OQ} - 5.39\text{D}_2 - 3.12\text{D}_3 + 0.58\text{D}_4 \\ & (3.53) \quad (18.78) \quad (1.69) \quad (1.81) \quad (1.76) \end{aligned}$$

$$\begin{aligned} R^2 &= 0.949, \text{ DW (adjusted for the gap in observations)}=1.92, \\ p &= 0.73 \\ & (0.12) \end{aligned}$$

$$\begin{aligned} \text{DFPPS} = & 116.23 - 0.042\text{PPS}^* + 0.899\text{DFPBS} - 0.432\text{DMP} \\ & (0.021) \quad (0.107) \quad (0.284) \\ & - 23.97\text{BMP} + 4.97\text{D2OQ} + 2.52\text{D}_2 + 5.89\text{D}_3 + 5.02\text{D}_4 \\ & (4.92) \quad (15.1) \quad (3.99) \quad (3.92) \quad (3.99) \end{aligned}$$

$$R^2 = 0.93, \text{ DW (adjusted for the gap in observations)} = 1.82$$

Figures shown in brackets are standard errors.

7.4 Evaluation of the Parameter Estimates

All of the parameters in all four equations have the expected sign except for the parameter associated with the BMP dummy variable

(which is discussed below) and the D2OQ dummy variable in the DFPBN equation. These equations indicate that the anticipated level of live pig supplies and the price inter-relationship between these four "markets" dominates buyers' price setting behaviour. This implies that unintended stock changes over any one quarter do not result in a significant modification of the initial pricing decision. It would appear that either unintended stock changes are not large or that unintended stock changes are important over shorter periods but that buyers are able to modify their prices significantly within any one quarter to bring the actual stock change very close to the desired stock change when changes in stocks are measured over the whole quarter.

The coefficients of determination are reported along with the equations (above) and indicate that between 94 percent and 95 percent of the variation in each farm price is explained by the changes in the explanatory variables. The elasticities implied by the estimation results are shown in Table 7-1.

As noted, the results indicate that unintended changes in stocks do not result in a significant impact on farm prices. None of the parameters for ΔS or representing ΔS^* (i.e. LICFBN, CDINT, or CHCON) are significant at the 10 percent level, (however all the latter variables do have standard errors smaller than the parameter estimate). It is possible that the standard errors for the LICFBN and CDINT variables are effected by multicollinearity although the correlation coefficients between them and the variable most correlated with them (i.e. PBN*) are only -0.65 and 0.57 respectively. However, these parameter estimates (if we were to accept them as insignificant) are not consistent with the extremely low (and completely insignificant) parameter attached to ΔS . These results imply that buyers are far more sensitive to a change in unintended stocks caused by changes in desired stocks than an identical size change in unintended stocks caused by changes in actual stocks.

Table 7-1

Elasticities Derived from the Farm Price Equations

DEPENDENT VARIABLE	INDEPENDENT VARIABLE									
	PBN*	PBS*	PPS*	PPN*	DFPBN	DFPBS	DMP	LIDFPBN ¹	DINT ²	CON ³
DFPBN	-0.86	-	-	-	-	-	-	0.38	0.14	0.26
DFPBS	-	-0.36	-	-	0.94	-	-	-	-	-
DFPPS	-	-	-0.27	-	-	0.93	-0.61	-	-	-
DFPPN	-	-	-	-0.39	0.67	-	-0.36	-	-	-

1. Calculated as the percentage change in DFPBN in response to a 1 percent change in the lagged value of DFPBN (not significant).
2. Percentage change in DFPBN in response to an increase in interest rates by 1 percent (not significant).
3. Percentage change in DFPBN in response to a 1 percent increase in total consumption of cured pig-meat (not significant).

Therefore the null hypothesis that unintended changes in the level of stocks over a complete quarter do not affect farm prices has to be accepted.

This result needs to be treated with suspicion. The proposition that buyers are able to manipulate prices within any one quarter sufficiently to maintain actual stock levels at their desired level between quarters requires further investigation. It is possible that unintended stock changes are very small. Chapter Five noted that the retail demand for cured products is only subjected to one important source of exogenous shock (i.e. income changes). Given that incomes are unlikely to fluctuate dramatically, exogenous shocks to the retail demand for cured products are likely to be small. On the supply side, it is possible that buyers can accurately anticipate changes in the supply of live pigs (or that they heavily discount "temporary" changes in supply when making pricing decisions).

If unintended stock changes are small buyers are more likely to be able to manipulate prices within the quarter to bring quarterly stock changes in line with desired stock changes. Further investigation is required to try and identify the size of unintended stock changes and buyers responsiveness to these changes within any one quarter. However, the result could also be due to data problems (i.e. a very poor estimation of buyers actual change in stocks). Appendix A discussed the estimation of this variable in detail and noted that it was one of the least satisfactory variables used in this study. An investigation currently underway to improve the stocks data available to the Board should give an indication of the accuracy of the series used in this study as well as improving the historical data needed for re-estimating the model.

The parameters associated with the 'anticipated trend production' variables, are significant at the 5 percent, 10 percent and 20 percent levels in the DFPBN, DFPBS, DFPPS, DFPPN equations respectively. However, all of the standard errors associated with these variables are likely to be affected by multicollinearity because of the close association between these variables and the D2OQ dummy variable. An estimation of the various correlation matrices supports this a priori suspicion; only in the case of the DFPBN equation is the correlation coefficient between these two variables less than 0.9.¹¹ This limits the usefulness of the individual parameters (although, because the relationship between these two variables will remain constant in time, it should not affect the usefulness of the equations for forecasting). The elasticities reported for the asterisk variables in Table 7-1 must be treated with suspicion.

When the model is re-estimated this problem could be overcome by removing the D2OQ variable from the model altogether and adjusting the pig production series to offset the impact of the 1973 grading classification change (i.e. make an

11. This coefficient in each equation is as follows; DFPBN (-0.6), DFPBS (-0.95), DFPPS (0.98), DFPPN (0.93).

adjustment to the first 20 observations in each of the production series to put them on the same grading classification basis as the later observations). This adjustment could be made on the basis of results presented in this study. However, further investigation into the likely impact of this grading change would provide a sounder basis on which to impose parameter restrictions on the various D2OQ variables in the model. For example, an investigation into the weight distribution of pigs slaughtered within grades and the wastage rates (or proportion of saleable cuts) of various carcass weight grades should provide the sort of evidence required to impose parameter restrictions on the model. These restrictions would ensure that the loss in any one weight grade as a result of the classification change would be exactly compensated for (after adjustment for wastage rates) by an increase in the other weight grade. Similarly such an investigation would provide the evidence necessary to ensure consistency throughout the marketing system (i.e. ensure that the estimated increase in one weight grade at slaughter was compatible with the estimated increase in the consumption of pig-meat derived from that grade). Obviously, a considerably amount of extra work is required before all of these (vertical and horizontal) restrictions can be applied with confidence. Until this type of investigation is carried out there would be no guarantee that the model would be improved if the D2OQ variable was replaced by adjusting the consumption and production series on the basis of the limited information available.

The elasticities between the various farm prices are all very high and are all significant at the 1 percent level. This reflects the very close association between prices in the various "markets". Their relative sizes are also credible. Traders are willing to transport bacon weight pigs when the supply and demand conditions in each region act to create a divergence between North and South Island baconer prices. We would also expect far more intimacy

between baconer and porker prices in the South Island than in the North Island. The porker "market" in the North Island is considerably larger than it is in the South Island (i.e. about 45 percent of the total market in the North Island compared with only 20 percent of the total market in the South Island). This larger market for pork weight pigs is associated with far more specialisation in the production and marketing of pork weight pigs in the North Island which provides some insulation from fluctuations in the baconer "market". The problems associated with transporting either live pigs or fresh pork between islands also provides some regional isolation in porker markets. These factors tend to support the direct price elasticities reported in Table 7-1 (e.g. it is not unreasonable to hypothesise² on a priori grounds that the North Island baconer price, through its effect on baconer prices in the South Island, would have a greater effect on South Island porker prices than North Island porker prices).

The impact of the farm-to-retail price margin on the farm price for pork is weak and neither of the parameters associated with the margin variable is significant at the 10 percent level (although the South Island parameter is significant at the 20 percent level). These results suggest that although it is difficult to maintain that changes in pork margins have no direct influence on porker prices, this influence is relatively minor.

Probably the most surprising, and interesting, results are the parameter estimates associated with the BMP variable (i.e. the dummy variable taking on the value of unity over the period during which the Board "supported" the price received by farmers). If the scheme did, in fact, support the farm price at higher levels than buyers would have been willing to offer then these parameters should have been positive (i.e. the farm price during the period of price support should have been higher than the level of production,

stocks, etc. would have warranted). However, apart from the parameter associated with the BMP variable in the South Island pork price equation (which is significant and negative), none of these parameters are significantly different from zero. This implies that the BMP scheme had no influence on the average level of farm prices over the period (and in fact actually depressed the farm price for porkers in the South Island).¹² However, it implies nothing about the effect the scheme would have had in any particular quarter. It is quite likely that the operation of the scheme acted to support farm prices during the first few quarters of operation but that continuation of the scheme over a prolonged period actually slowed the recovery in farm prices. The BMP could well have acted as a basic minimum price during the early phases of operation and a basic maximum price over the latter phases.

Why should the BMP scheme act to depress farm prices? The Board's own assessment of the scheme's operation notes that:

"it became obvious that the main traders would use the Board as their wholesale supplier when and where required and those companies who had traditionally been wholesalers to the trade opted out for the time that the Board was involved." 13

As noted in Chapter Three, this report also observed that:

"Meat had to be sold as quickly as possible on the local market to allow money to be available to purchase pigs and keep the back account within the limits laid down".¹⁴

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12. Unfortunately, the very high value for \hat{p} in the North Island equation for baconer pigs does complicate this analysis. In this case the dummy variable does include a -0.94 "observation" in the quarter following the BMP period. The non-significant coefficient therefore also implies that the farm price did not rise abnormally after the BMP buy-in halted.
 13. Pork Marketing Board, "BMP Scheme Report", Pork Industry Gazette, p.52.

and that during the last nine to twelve months of the scheme's operation farm prices were set below the level needed to keep efficient producers profitable in an effort to "depress production". Given these conditions it is quite possible for the operation of the BMP scheme to have depressed farm prices. It appears that the Board merely performed a whole-sale function being unable to direct pig-meat off the local market (either into stocks or export) because of a lack of funds. Whether or not farmers received a higher payout then depends on whether or not the Board was willing and able to pay more for pigs than traders who would normally perform the wholesale function. If the Board's payout was below what traders would be willing to offer for the same quantity of live pigs, traders did not have to enter the market (and hence bid up the price) to obtain supplies. Although the Board was both willing and able to set higher prices for pigs than the trade when the stabilisation account was large, its ability to maintain these prices declined with the stabilisation account balance. Near the end of the period, when the Board was trying to "depress production", it is quite possible that the BMP was actually set at a level below that which traders would have been prepared to offer for the same quantity of live pigs.

There is also good reason to accept that the operation of the BMP scheme had a particularly severe effect on the price of porker pigs in the South Island. The Board purposely set a very low BMP for porker weight pigs and offered a discounted BMP to South Island producers. Although only a limited number of pork weight pigs were sold to the Board, the publication of a very low BMP for these pigs in the South Island would have made it very easy for South Island wholesalers to lower the price they had to pay for these pigs for the limited period of Board involvement.

The other dummy variables in the equations are of varying importance. The effect of the change in grading classification is only significant in the South Island baconer equation.

Although this variable is insignificant in the other equations it has the wrong sign in only the North Island baconer equation. An examination of the data indicates that the grading change had a more important impact on individual grades in the South Island. However, these results are not altogether consistent with the results of the other equations in the model which indicate that the grading change did result in some arbitrary change in the numbers of pigs in each category. We would have expected that the relationship between farm price and production to have "shifted" as a result of the grading change. These results confirm the value of an investigation into the influence of the grading change that would allow a reasonable adjustment of the production series and, therefore, the removal of the D_2OQ variable from the model.

Seasonal influences do not appear to affect price setting behaviour of buyers in the baconer market although they do appear significant in the porker equations. Given the problems associated with the specification of the fresh pork component of the model, these seasonal influences could well be acting as substitute demand factors. After adjusting for the influence of ρ , these dummies indicate that prices tend to be higher in the fourth quarter (both islands), whilst the results for the other quarters are mixed (i.e. different results in each island). An increase in the demand for fresh pork occurs in the fourth and second quarters.

Finally, the stability of the parameter estimates in all four price equations was tested following the procedure outlined in earlier chapters. Five observations were dropped from the end of the sample period and the observations re-estimated using 27 observations and the stability of the parameter estimates tested using an F statistic. The results are shown in Table 7-2. Because the computed F statistic is less than the critical value of the 1 percent level we accept that the structural coefficients in all four equations are stable (i.e.

Table 7-2

Testing the Structural Stability of the
Farm Price Equations

n	BACONER				PORKER			
	North		South		North		South	
	32	27	32	27	32	27	34	29
Constant	257.17	355.4	70.99	69.35	125.32	40.67	116.23	143.6
PBN*	-0.028	-0.050						
AS	-0.00006	-0.0011						
LICFBN	0.387	0.947						
CDINT	-0.018	0.008						
CHCOW	0.005	0.007						
PBS*			-0.022	-0.019				
DFPBN			0.899	0.875	0.578	0.715		
PPN*					-0.019	-0.0048		
PPS*							-0.042	-0.047
DFPBS							0.899	0.993
DMP					-0.249	-0.007	0.432	0.657
BMP	-4.6	1.6	-2.33	-4.17	2.55	-2.6	-23.97	-16.92
D20Q	42.11	-23.2	-40.59	039.77	11.23	-10.17	4.97	8.56
D2	-1.29	-0.8	05.22	-3.69	-5.39	-5.2	2.52	2.78
D3	-5.02	-7.01	-1.41	-0.44	-3.12	-2.4	5.87	7.54
D4	-6.21	-5.80	3.38	3.39	0.58	1.5	5.02	6.99
P	0.94	-0.04	0.33	-0.01	0.73	0.38	N/A	N/A
e ²	867.4	781.45	752.43	436.18	390.48	313.06	1,487.03	1,218.36
F*	0.35		2.75		0.88		0.88	
0.01(5,n-k)	4.04		3.94		3.94		3.86	

do not change as the sample size decreases). However, it should be noted that the South Island baconer price equation is least satisfactory in this regard.

The results presented in Table 7-2 are extremely interesting with respect to the incidence of autocorrelation in the equations; the value for $\hat{\rho}$ is insignificant in the two baconer equations and has been virtually halved in the North Island porker equation. When these new equations are used to predict the last five values, they consistently overstate the farm prices (i.e. the autocorrelation in the original 2SPC equations was considerably aggravated by the last five observations).

7.5 Conclusion

This chapter has discussed the specification, estimation and evaluation of the farm price equations used in the New Zealand Pig-meat Model. A number of important conclusions can be drawn from this analysis concerning price determination for live pigs and the impact of the Board's operation of the BMP scheme during 1977/78:

- (a) It would appear that buyers are able to successfully anticipate changes in supply and demand conditions and adjust prices without suffering large changes in unintended stock levels and/or manipulate prices within any one quarter to moderate the size of unintended changes in stocks between quarters. Therefore it is buyers' perceptions of current "trend" levels of production, rather than changes in unintended stock levels, that dominate movements in farm prices between quarters. However, further investigation is required into stock levels and traders stock management to confirm this conclusion;

- (b) There also appears to be a strong link between movements in the different classes of farm price. Given the opportunity for substitution in production this degree of association between these prices is credible;
- (c) This evidence indicates that the Board's active intervention in the market during the 1977/78 period did not have a significant effect on farm prices for baconers and porkers in the North Island or baconers in the South Island and actually appears to have depressed the price of pork weight pigs in the South Island below the level they would otherwise have been over the period taken as a whole. Although these results are surprising they are not incredible given the way the BMP scheme operated in practice.

CHAPTER EIGHT

THE FARM PRODUCTION EQUATIONS : SPECIFICATION, ESTIMATION AND EVALUATION

8.1 Introduction

This chapter discusses the specification, estimation and evaluation of the six farm production equations used in the New Zealand pig-meat model. The first section discusses the specification of production equations and briefly reviews two overseas studies of pig production.¹ Although these studies provide a useful background to the specification of pig supply functions in New Zealand, data limitations restrict the application of the types of specification used overseas.

The second section discusses a generalised specification of pig supply response equations in New Zealand. This section discusses the major determinants of supply, the lags inherent in the pig production cycle, and a chronology of the major production decisions taken by producers. Most of the important characteristics of the pig production industry that effect supply have already been discussed.

The third section discusses the specification and estimation of each of the six farm production equations used in the New Zealand pig-meat model and briefly evaluates the parameter estimates for each equation in isolation. Finally, the stability of the parameter estimates is evaluated and the consistency of these parameter estimates (when compared across equations) is discussed.

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1. L. D. McClements, "A Model of Pig Supply", Journal of Agricultural Economics, Volume 20, No.2, May 1969, pp 241-250; R. A. Richardson and J. G. O'Connor, "Changes in the Structure of Supply Response in the Australian Pig Industry", Review of Marketing and Agricultural Economics, Volume 46, No.3, December 1978, pp 220-237.

8.2 Brief Review of Previous Studies

Labys discusses five major classes of determinants of producers supply response, (e.g. economic, ecological, technological, institutional and uncertainty determinants) and the deviation of static and dynamic relationships from microeconomic theory.² Economic factors normally included in supply relationships are the market prices of the commodity and the prices of the inputs used in the production process. The supply relationship is derived from the proposition that producers try to maximise profits subject to the production function constraint.³ In terms of the underlying cost relationships, the supply curve of a market or industry represents the summation of the relevant portion of the marginal cost curve for individual producers. Therefore, in the static formulation, supply is usually considered to be a function of the price of the commodity of interest, the prices of inputs to the production process, prices of other commodities closely related in production and non-economic determinants such as technological or institutional factors.

Ecological determinants usually relate to yield levels and can include the effects of disease and climate. Although seasonal influences are moderated by intensive pig rearing systems, Clements did find these factors important in determining the number of sows not in pig in Northern Ireland.⁴ Technological determinants usually relate to innovations directly affecting the production process. However, as noted in Chapter Two, it is probable that improvements in dairy processing technology have had the greatest single impact on the pig industry in the late 1960s and early 1970s. Richardson

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2. W. C. Labys, Dynamic Commodity Models; Specification, Estimation and Evaluation, p.36-47.
 3. A further explanation of the derivation of supply functions appears in J. Henderson and R. Quandt, Microeconomic Theory, New York, McGraw-Hill Book Co., 1971; L. R. Klein, An Introduction to Econometrics Englewood Cliffs: Prentice-Hall, 1962; and E.W. Kehrbery, "Determination of Supply Functions from Cost and Production Functions", Agricultural Supply Functions, E. O. Heady, et al (Eds), Ames: Iowa State University Press, 1961, pp 139-151.
 4. L. D. McClements, op cit, p.244

and O'Connor include an institutional variable (a dummy variable representing the imposition of wheat quotas) in their national sow inventory equation for Australia.⁵

Although institutional factors are unlikely to have exerted a major influence on pig supply in New Zealand, the 1973 grading classification change is likely to have had a major influence on recorded pig production.

Finally, determinants influencing supply that reflect uncertainty are often expressed in the form of expectations (especially producers expectations about future price levels). Labys notes that:

"Nerlove suggests a number of certainty equivalents that might transform expectational variables into ones which are measurable.⁶ Among these are the extrapolative equivalent, which assumes that future values of a variable will relate to its past value; the adaptive equivalent, which suggests that previously perceived errors must also be taken into account; and the rational equivalent, which implies that predictions will be made consistent with the economic model or assumption followed".⁷

The influence of uncertainty is particularly important in modelling pig supply because producers have to adjust the level of matings in the breeding herd on the basis of some expectation of the price they will receive when the resulting progeny are slaughtered (i.e. decisions have to be based on expected price levels more than 12 months ahead).

Apart from identifying the major determinants of producers supply response, it is necessary to consider whether or not the supply relationship is static or dynamic. McClements

5. Richardson and O'Connor, op cit, p.227

6. M. Nevlove, "Time Series Analysis of the Supply of Agricultural Product", in Agricultural Supply Functions, E. O. Meady, et al

7. (eds) p.45-49.

W. C. Labys, op cit, p.37

assumes that farmers are constrained in adjusting the size of the pig breeding herd in any one quarter:

"The breeding herd is limited in its response to economic stimuli for two reasons. First, the number of sows not in pig in the previous quarter and therefore available to farmers for breeding will influence the size of the breeding herd in the current quarter. Second, for various other reasons farmers are unlikely to adjust completely to economic forces in one period. Uncertainty as to the permanence of price changes and prior resource commitments are obvious reasons for this inertia."⁸

This partial adjustment hypothesis can be incorporated into the supply function and combined with a suitable expectations hypothesis to derive an estimating form. Desired supply is assumed to be a function of expected future prices:

$$q_t^* = a_0 + a_1 P_t^* + a_2 Z_t \quad (8.1)$$

where:

q_t^* = desired supply
 P_t^* = expected price
 Z_t = predetermined variables

because farmers cannot fully adjust actual supply to desired levels in one quarter,

$$q_t - q_{t-1} = \delta(q_t^* - q_{t-1}) \quad (8.2)$$

where:

q_t = actual supply
 δ = coefficient of adjustment ($0 < \delta < 1$)

combining these two equations:

$$q_t = \delta a_0 + \delta a_1 P_t^* + \delta a_2 Z_t + (1 - \delta) q_{t-1} \quad (8.3)$$

8. L. D. McClements, op cit, p.245

Obviously different price equations hypotheses will result in different estimating equations.

Both the McClements and Richardson and O'Connor studies of pig supply divide the supply response into two distinct relationships. The first relationship attempts to explain the size of the breeding herd while the second links the final production of slaughter pigs to a given breeding herd size. This is a very useful division of the production process and is adopted in a number of American studies of pig supply.⁹ Unfortunately lack of quarterly data on the size of the sow herd precludes the adoption of this approach in the current study.¹⁰

In his study of pig supply in Northern Ireland, McClements estimated a four equation model using quarterly data for the period 1961 to 1967. McClements equations explained the numbers of sows and gilts in pig, the supply of fat (slaughter) pigs, the price for store pigs and the number of sows not in pig. Basically the model expresses the size of the breeding herd as a function of the profitability of production (i.e. feed costs and pig prices) and expected prices using the hypothesis ^{that} the breeding herd is only partially adjusted to its equilibrium level in any one period. In an unusual move McClements has included the price of fat sows (as a proxy for the expectations of the breeding sector in future pig prices) as well as actual prices of store pigs as an explanatory variable. Therefore the equation explaining the size of the Northern Ireland breeding herd is the same as (8.3) above where P_{t-1*} = the price of fat sows and the Z_{t-k} variables are the price of store pigs, the cost of

9. See, for example, E. R. Arzac and M. Wilkinson, "A Quarterly Econometric Model of United States Livestock and Feed Grain Markets and Some of its Policy Implications", American Journal of Agricultural Economics, Volume 61, No.2, May 1979, pp 297-304.

10. Although annual estimates of the size of the sow herd are available it is impossible to estimate the number of sows on farms each quarter (even given the sow kill) because no quarterly figures on gilt retention are available. Gilts are maiden sows.

feed, the number of sows not in pig and seasonal dummy variables. It is difficult to appreciate why the 'number of sows in pig' variable is included. When the equation for this variable is substituted into the breeding herd equation it only adds two more (lagged dependent) variables to the original estimating form.

The number of sows and gilts in pig are then (separately) used to determine the production of fat pigs. McClements also includes a variable to account for the influence of increasing breeding herd size on fat (slaughter) pig production (i.e. he takes explicit account of the fact that increasing the size of the breeding herd results in an immediate reduction in the number of fat pigs for sale).

The lags in the McClements model are illustrated in Figure 1 of his paper.¹¹ He divides the complete cycle from the commencement of decision making to slaughter into four periods: decision making to mid pregnancy (three-five months), mid pregnancy to birth (two months), birth to store (three-five months) and store stage to slaughter (three months). Therefore, in McClements model it takes about 12 months from the time the decision to increase production is made, until the "fat" pigs are eventually slaughtered. The lags in his model reflect the lags in this cycle.

These four equations were estimated using OLS. McClements found that the net effect of a 1 percent rise in feed prices and fat pig prices was a 1.5 percent reduction and a 0.4 percent increase in the size of the breeding herd respectively.¹²

Richardson and O'Connor estimated two equations explaining pig supply in Australia (i.e. an equation for sow numbers and an equation linking sow numbers to final production) using annual data for the period 1953/54 to 1975/76. This

11. Ibid, p.243

12. Ibid, p.248

simple model was recursive. Like McClements, Richardson and O'Connor used a production cycle (including both biological and economic lags) to determine the lag structure of their model. They assumed slightly longer periods to finish bacon weight pigs in the Australian situation:

"A producers decision to retain and join sows in month one would lead to marketing of porkers $10\frac{1}{2}$ to $12\frac{1}{2}$ months later, or of baconers $13\frac{1}{2}$ to $16\frac{1}{2}$ months later. Further lags would be associated with decisions to increase production; for example gilts cannot be mated until about 9 months of age, and it takes time to purchase additional sows and associated inputs to expand production. There may (also) be delays in forming price expectations...."¹³

They used a "general model of supply response"¹⁴:

$$S_{t-1} = f(\bar{P}_t, Z_{1t-1})$$

where:

S_{t-1} = number of sows joined in period t-1
 \bar{P}_t = expected pig price in period, and
 Z_{1t-1} = an exogenous shifter in period t-1

and linked the size of the breeding herd to pig slaughter using a second equation:

$$PS_t = f(S_{t-1}, Y_t)$$

where:

Y_t = an exogenous shifter in period t
 PS_t = slaughter of pigs in period t

They adopted Nevlore's geometrically declining lag (of past prices) to determine \bar{P}_t :

13. R. A. Richardson and J. G. O'Connor, op cit, p.224

14. Ibid pp 224-228

$$\bar{P}_t = \sum_{r=0}^{\delta} \beta(1-\beta)^r P_{t-r-1}$$

which yielded the following estimating form:

$$St_{-1} = f'(St_{-2}, PPt_{-2}, D_1, D_2)$$

$$PSt_t = f''(ES_{t-1})$$

where:

- PPt-2 = weighted average of pig prices for the October to September period prior to March 31 of year t-1
- PFt-2 = weighted average of grain prices for the December to November period prior to March 31 of year t-1
- ES_{t-1} = sow numbers in Australia at 31 March in year t-1 as estimated in the first equation
- D_i = Dummy variables, i=1, 2

Unlike McClements model, Richardson and O'Connor do not use a partial adjustment hypothesis to derive their estimating equation (the lagged dependent variables parameter is the "coefficient of expectation" rather than the "coefficient of adjustment") and neither do they hypothesise that current production levels will decline if the sow herd is increased. Given the different data periodicities, the first difference is reconcilable. However Richardson and O'Connor's slaughtering equation must be considered an oversimplification of reality.

Richardson and O'Connor reported short run elasticities of supply with respect to pig prices of between 0.72 and 1.06 (for different sample periods) and elasticities of supply with respect to feed costs of between -0.53 and -1.12.¹⁵

15. Ibid, p.230

8.3 Generalised Specification of Pig Supply Response in New Zealand

This section discusses the major determinants of New Zealand pig producers supply response and develops a production cycle which can be used to help identify the important lags in this response. The major production decisions taken by the farmer during this production cycle are also identified.

8.3.1 The Determinants of Production

Chapters Two, and Three discussed the structural characteristics of the pig industry in detail and illustrated the impact that the declining availability of dairy by-products has had on the character of the industry. It was apparent from that discussion that these structural changes would have to be clearly identified in the production equations even though the estimation period had been selected to minimise the impact of these structural changes. It was also apparent from the discussion in these chapters that, although some city waste and dairy by-product feeding persists, the pig industry has become a predominantly grain based economy. Given that feed costs represent about 70 percent of the total costs of producing a slaughter pig, these costs are likely to be a major determinant of pig supply. However, it is unlikely that these costs are the only determinants on the cost side. The quantity of dairy by-product available is also likely to influence feed "costs".

The opportunity cost of labour could also be important; especially with respect to larger part time and smaller full time producers whose production decisions are the most significant influence on the stability of production (See Table 3-2). The Agricultural Statistics indicate that, of the total number of working owners in the "Pig Farming" and "Pig Farming with Other" farm types, 35 percent and 33 percent respectively worked less than 30 hours per week on their farms

(compared with 26 percent for all farm types).¹⁶ A large number of these working owners are likely to be part-time pig producers. The production decisions of these producers are likely to be sensitive to the real wage rate (i.e. pig production has to compete with all other forms of economic activity for the time of these producers).

It is unlikely that the profitability of other types of farming activity will have a major impact on pig production. Yandle observed an inverse relationship between pig numbers and the price of butterfat during the period when pig production was closely associated with dairy production.¹⁷ However, Chapter Two noted that this dairy-pig production regime was eroded throughout the 1960s and by 1970, 77 percent of dairy factory suppliers supplied whole-milk. The 1978 Agricultural Statistics indicate that only 8 percent of the national pig herd was held on dairy farms, and over 64 percent of the total pig herd was operated by farmers who relied on pig production as their primary source of income.

Pig production is therefore likely to be primarily determined by the price of slaughter pigs, the cost of feed, the supply of dairy by-products, the level of real wages, seasonal factors, and producers expectations about future price movements.

8.3.2 Lags in the Production Cycle

Because of the diversity of pig production systems it is very difficult to quantify an "average" production cycle. The production cycle will vary according to the type of feed used, the capital intensity of production (which implies a varying degree of control over the pigs environment), the

16. Department of Statistics, Agricultural Statistics 1975-76, Table 40, p.62.

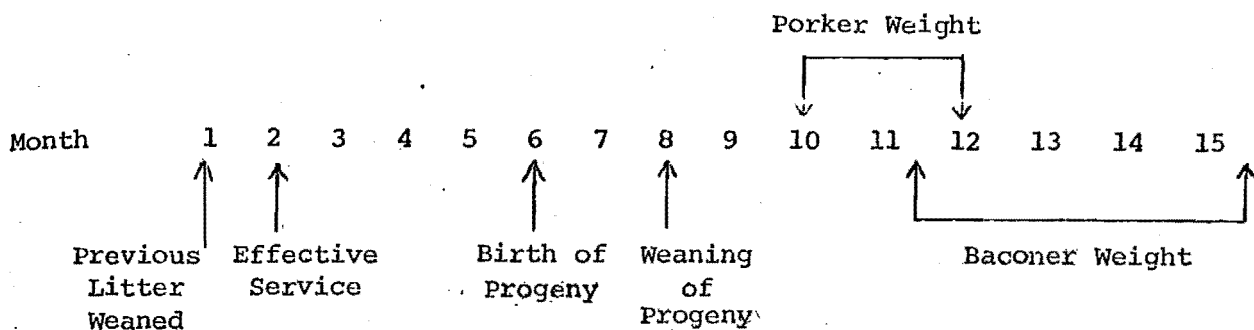
17. C. A. Yandle, An Econometric Study of the New Zealand Meat Market, 1968, p.15.

management ability of the farmer, and the type of pig (i.e. porker or baconer) that the farmer is attempting to produce. Therefore both management and biological factors can have a major impact on the length of time taken from the weaning of one litter to the slaughter of the next. For example, it is technically possible (allowing for a 16 week gestation period, a six week lactation period and a one week period between weaning and remating) to obtain 2.26 litters per sow per year. However, management factors can alter the lactation period (from between three weeks and eight weeks in a commercial situation) and the period from weaning to remating (e.g. if sows do not conceive at first mating three weeks are lost). In a survey covering only nine meal feeding farms, the PIC found that the farrowing index (litters/sows/year) averaged 1.87 with 2.1 for the top 30 percent and 1.57 for the bottom 30 percent.¹⁸ This is consistent with a four week weaning to remating interval and an eight week suckling period on the "average" farm in the survey.

The period from birth to slaughter is also highly variable. Using growth rates of 0.75kg average daily liveweight gain (excellent) to 0.37kg average daily liveweight gain (very poor) the Council has calculated that the period from weaning to slaughter at bacon weight can vary between 14.2 and 29 weeks.¹⁹ Using similar calculations, the period from weaning to slaughter at pork weight would vary between 7.8 and 15.8 weeks. Combining the "average" weaning-to-weaning lag (the breeding lag) with the variable weaning-to-slaughter (growing) lags would produce the following production cycle:

18. Pork Industry Council, Pig Production and Management Manual, 1977, Production Section, p.7.

19. Ibid, Production Section, p.8.



This lag structure is very similar to that reported by Richardson and O'Connor for Australia and longer than that used by McClement for Northern Ireland.

Apart from these lags associated with the production cycle, additional lags are associated with decisions to change the level of production. Firstly there are further biological and management lags. Although individual farmers can buy capital stock, the aggregate level of capital stock cannot be increased in this manner. Changes in the national sow herd will be a result of increasing the number of gilts in the herd and/or decreasing the number of sows being culled from the herd. Biologically, the ability to quickly increase the aggregate level of matings is more constrained than the ability to achieve a corresponding decrease. Provided works space is available, the number of matings can be reduced by simply killing capital stock and potential capital stock. However, if farmers wish to increase the number of matings in the herd their ability is constrained by the number of potential cull stock that can be retained (e.g. on husbandry grounds), the number of female bacon weight pigs of breeding worth on hand, and the two to three month lag required before bacon weight pigs reach a matable size. However, the desire to maintain a steady throughput of pigs on the farm (to keep utilisation of the available pen space up) also limits the farmers willingness to make sharp adjustments to the number of matings. Therefore, in practice, it is unlikely that the lag structure associated with increases and decreases in the size of the breeding herd is asymmetrical. It is also

important to note that, although management practice will smooth adjustments in the size of the breeding herd between weeks and months, adjustment can still be relatively speedy over a quarterly period. Assuming an average 1.87 farrowing index, 46 percent of the breeding herd will farrow in any one quarter which means that farmers can change the level of matings and not effect the continuity of production as long as the change was spread over two quarters.

Secondly, there may well be delays in farmers reactions to price changes (i.e. a lag between changes in prices and farmers decisions to change the size of the breeding herd). This could be due to farmers uncertainty about the permanence of price changes (as McClements suggests) and reflects farmers price expectations behaviour. McClements makes the fairly arbitrary assumption that farmers make decisions concerning the level of matings in the herd about one month after a given price change.²⁰ The actual lag between price changes and farmers' responses will depend on the way farmers form price expectations. For example, farmers may have extrapolative expectations about prices based on an intuitive cyclic model of the market. This would imply that farmers would react quickly to price changes perceived as the start of cyclic upturns or downturns.

Taking the economic, biological and management lags together it would be reasonable to expect that changes in the slaughter of bacon weight pigs would occur in response to price changes that had occurred some five to seven quarters previously. It would also be reasonable to assume that most pork weight pigs are sold in the quarter before bacon weight pigs reach marketable weight.

20. L. D. McClements, *op cit*, p.242

8.3.3 The Generalised Specification of the Supply Response - A Model of Farmers' Production Decisions

Pig Producers have two main production decisions separated chronologically; the level of productive capacity (or matings) and the weight at which pigs should be marketed. As the level of production is determined by these decisions, the production relationship must reflect the factors important in determining the level and timing of these decisions.

A decision to change the number of matings in any one quarter will have two major effects: it will have an inverse impact on production in the same quarter and a larger direct impact on production five to seven quarters after the decision is made. The immediate inverse impact occurs as a result of an increase in the number of slaughter weight pigs retained for breeding purposes and the lagged positive impact is a result of the increased productive capacity. This decision is based on farmers' perceptions of the relative profitability of production at point of sale (i.e. five to seven quarters ahead). It is therefore affected by factors that determine the relative profitability of pig production (pig prices, feed costs, dairy by-product supplies and the level of real wages), farmers' expectations about the level of these factors when slaughter weight pigs are sold, and farmers' ability to change the herd size within any one quarter.

Without considerable prior investigation it is impossible to determine how pig farmers in New Zealand form relative price expectations. Therefore a number of expectations "models" were used in specifying the production equations estimated in this study. It is also difficult, a priori, to determine whether or not farmers will adjust partially or fully to price changes given any particular lag structure. Finally, it is also difficult a priori to determine the exact length of lag between price changes and output responses. These difficulties require that a number of specifications be pre-tested (i.e. on a smaller sample size) before the final specification is chosen. Initially

polynomial distributed lags (Almon lags) were used with the maximum number of periods (i.e. seven quarters) and minimum number of restrictions. However, the Almon variables so calculated suffered from serious multicollinearity problems so this procedure was discontinued and pointⁱⁿ estimates of lag values specified.

The general specification of the production equations includes both partial adjustment and extrapolative price expectations behaviour. Using the same notation as above we can derive a generalised estimating form with both partial adjustment and extrapolative price expectations:

$$q_t^* = a_0 + a_1 P_t^* + a_2 Z_t \quad (8.1)$$

$$q_t - q_{t-1} = \delta(q_t^* - q_{t-1}) \quad (8.2)$$

$$q_t = \delta a_0 + \delta a_1 P_t^* + \delta a_2 Z_t + (1-\delta)q_{t-1} \quad (8.3)$$

When price expectations are extrapolative:

$$P_t^* = P_{t-k} + \beta(P_{t-k} - P_{t-k+1}) \quad (8.5)$$

where k = length of economic, biological and management lags.

Substituting 8.5 into 8.3:

$$\begin{aligned} q_t &= \delta a_0 + \delta a_1 (P_{t-k} + \beta(P_{t-k} - P_{t-k+1})) + \delta a_2 Z_t + (1-\delta)q_{t-1} \\ q_t &= \delta a_0 + \delta a_1 P_{t-k} + \delta a_1 \beta (P_{t-k} - P_{t-k+1}) + \delta a_2 Z_t + (1-\delta)q_{t-1} \\ &= \alpha_1 + \alpha_2 P_{t-k} + \alpha_3 (P_{t-k} - P_{t-k+1}) + \alpha_4 Z_t + \alpha_5 q_{t-1} \end{aligned} \quad (8.6)$$

Equation 8.5 states that expected price is a function of the previous actual price plus or minus a fraction of the previous price change. If producers have an intuitive cyclic model of the market we would expect β to be positive (implying that producers expect prices to continue going up or down). This implies that producers are unable to accurately predict

The second major production decision made by producers concerns the weight at which live pigs should be marketed. This decision will be made by different types of producers at different stages in the production cycle and in response to different factors. When the dairy-pig production regime was predominant the market weight of pigs was a function of the availability of skim-milk. When plenty of skim-milk was available virtually all pigs were taken on to the maximum slaughter weight. On the other hand, grain feeders are sensitive to the relative farm price of pork and bacon weight pigs as well as the feed costs involved in increasing slaughter weights. We would expect a high baconer/porker price ratio combined with low feed costs to produce the greatest diversion of slaughter pigs into the baconer weight category.

What is less obvious is the stage in the production process at which producers will make this decision. "Specialist" porker producers are likely to consider the relative price of each grade when the production capacity decision is made and modify it in the light of eventual relative profitabilities. This would minimise the problems caused by production discontinuities while allowing for these costs to be traded off against the gain which may be realised in the final period. Specialist pig "fatteners" (who buy weaner pigs and keep them through to slaughter weight) are likely to make their decisions at weaning age and modify them in the light of realised prices. However, the greatest number of producers are likely to adjust production plans in the light of realised prices (i.e. make the decision on marketing weight when pigs reach porker weight).

8.4 Specification, Estimation and Evaluation of each of the Farm Production Equations Used in the New Zealand Pig-Meat Model

Because of the distinctive nature of each of the six production types identified in this study the specification, estimation

and evaluation of each of these equations is treated separately in this section. A brief evaluation of the equations, as a group, appears in section 8.5 along with an examination of the stability of each equation. The evaluation in this section is primarily concerned with the internal consistency of each equation, however in section 8.5 we are primarily concerned to evaluate parameter consistency between equations.

8.4.1 Production of Bacon Weight Pigs in the North Island

The specification of this equation is very similar to the generalised specification discussed in section 8.3 above. Supply lags of between five and seven quarters were tested and the five quarter lag gave best results. Therefore, production is assumed to be a function of:

- (a) Factors determining the relative profitability of pig production in the North Island lagged five quarters. These factors are the farm price of baconer pigs, the cost of feed, the "trend" supply of skim-milk and the real wage rate. Apart from the real wage rate, all variables describe North Island conditions only. The trend supply of skim-milk is a simple four quarter moving average and was explicitly included to reflect the structural changes that have occurred in the industry. The change in the farm price of baconer pigs was also included to reflect extrapolative expectations. These variables determine baconer producers' level of matings (i.e. the change in production capacity). Therefore we would expect the lagged 'farm price' and 'average skim-milk supply' variables to have positive parameters and the lagged 'real wage' and 'feed cost' parameters to be negative.

- (b) Factors determining the relative profitability of different marketing weights for live pigs. Unfortunately, because of multicollinearity problems, the baconer/porker farm price variable could not be included. Therefore these factors are represented by the 'farm price for porker pigs' and the 'feed cost' variables lagged one quarter. We would expect the estimated parameters for these variables to be negative.
- (c) The factors determining the relative profitability of pig production in the current period. Lagged five quarters these factors determine the number of bacon weight pigs retained for breeding purposes. Therefore we would expect the signs of the parameters associated with these variables to be opposite to those noted in (a) above. However, the current cost of feed was rejected as an explanatory variable because it was insignificant and had an incorrect sign. This result could have been due to multicollinearity between this variable and lagged feed cost. Further experimentation with the form of these variables may overcome this problem (e.g. the variables could be combined using a priori weights calculated on the basis of the variable's importance in net receipts (e.g. "gross margins" could be used)).
- (d) Skim-milk production lagged one quarter was used as a proxy for the seasonal impact of dairy by-product fed pigs coming onto the market. We would expect this parameter to be positive.
- (e) Seasonal dummies were included was a dummy variable to take account of the influence of the 1973 grading classification change.

In the original specification the lagged dependent variable was also included in the equation (as a result of the adoption of the partial adjustment hypothesis) however this variable was very insignificant so the partial adjustment hypothesis was rejected for North Island bacon producers.

This specification was estimated using quarterly observations for the period 1970 (first quarter) to 1979 (second quarter) using 2SPC. Data for the supply of skim-milk prior to 1968 was used to allow the 'average skim-milk supply' variable to be lagged five quarters without having to sacrifice degrees of freedom. This estimation yielded the following result:

$$\text{PBN} = 6,879.74 + 25.04 \text{ L5FPBN} + 6.80 \text{ L5CFBN}$$

(7.82) (4.93)

$$-4.44 \text{ L5FEDN} - 2.58 \text{ L5WGE} + 0.759 \text{ L5ASN}$$

(3.99) (2.19) (0.4189)

$$-33.31 \text{ L1FPPN} - 9.50 \text{ L1FEDN} + 0.397 \text{ L1SKN}$$

(15.68) (8.03) (0.07)

$$-4.646 \text{ DFPBN} + 3.34 \text{ DWAGE} - 1.288 \text{ ASKMN} - 1,253.45 \text{ D20Q}$$

(11.39) (2.98) (0.410) (525.01)

$$+ 507.7 \text{ D2} + 192.2 \text{ D3} + 451.5 \text{ D4}$$

(224.9) (274.0) (236.4)

$$R^2 = 0.83, \text{ DW} = 1.9 \text{ (figures in brackets are standard errors)}$$

where:

- PBN = Production of bacon weight pigs in the North Island (tonnes)
- L5FPBN = Real farm price of baoncers in the North Island lagged five quarters
- L5CFBN = Change in real farm price of North Island bancers lagged five quarters.
- L5FEDN = Real Feed costs in the North Island lagged five quarters
- L5WGE = Real average weekly wage rate lagged five quarters
- L5ASN = Average skim-milk production in North Island lagged five quarters.
- L1FPPN = Real farm price of porkers in the North Island lagged one quarter
- L1FEDN = Real feed costs in the North Island lagged one quarter

DFPBN = Real farm price of baconers in the North Island
 DWAGE = Real average weekly wage rate
 ASKMN = Average skim-milk production in North Island
 D2OQ = Dummy variable for change in grading classification
 Di = Seasonal dummies ($i = 2, 3, 4$)

All the parameters in the equation have the expected sign and the explanatory variables explain 83 percent of the variation in the dependent variable. The Durbin-Watson statistic indicates that no autocorrelation is present. Although all the variables except the current farm price of baconers and D3 have smaller standard errors than parameter estimates, L5FEDN, L5WGE, DWAGE, L1FEDN and L5CFBN all have parameters not significantly different from zero at the 10 percent level. However, multicollinearity is likely to have had an influence on the standard errors of some of these variables.

The correlation coefficient between the current real baconer price and the lagged real porker price is 0.78 and although the figures in Table 8.2 indicate that these two parameters are reasonably stable, the lagged porker price has increased while the baconer price has decreased. The parameter attached to L1FPPN also appears to be too large on a priori grounds; it implies too much substitutability between porker and baconer production. The insignificance of the current baconer price is also implausible. We would expect a low parameter value attached to this variable but we would expect it to be significantly different from zero. Given the probability that multicollinearity has affected both L1FPPN and DFPBN parameter estimates, it would be foolish to reject the current baconer price as being insignificant.

The relative size of the current and (five quarter) lagged baconer price elasticities are acceptable (See Table 8-3). A 1 percent increase in the baconer price will result in a 0.15 percent decrease in the supply of baconer weight meat in the same quarter which is equivalent to about 83

83 extra gilts produce 8 pigs per litter an extra 50 tonnes of pig-meat should be produced in quarter $t+5$. At average weights, this would represent a 1.19 percent increase in production which is virtually identical to the (five quarter) lagged baconer price elasticity. The price elasticity of supply of 1.1 is very similar to similar elasticities reported for Australia by Richardson and O'Connor.

The relative sizes of the five quarter lagged and current real wage and skim-milk variables are not as acceptable as the comparable baconer price parameters. The current value parameters for these two series are both larger than the lagged value parameters (the opposite to what would be expected on a priori grounds). It is possible that multicollinearity has affected all of these parameter estimates. A matrix of the largest correlation coefficients associated with these variables is reproduced in Table 8-1 below. However, the figures presented in Table 8-3 indicate that all of these parameters are reasonably stable.

Table 8-1

Correlation Matrix of the Highest Correlation Coefficients
Between Explanatory Variables in the North Island
Baconer Production Equation

	<u>L5WGE</u>	<u>L5ASN</u>	<u>DWAGE</u>	<u>ASKIMN</u>	<u>LIFEDN</u>
L5ASN	-0.80	1.0	-0.50	0.98	-0.41
L1SKM	-0.62	0.74	-0.54	0.76	-0.26
ASKIMN	-0.85	0.98	-0.56	1.0	-0.34
D2OQ	-0.75	0.89	-0.48	0.87	-0.60

Finally, the relative size of the one quarter and five quarter lagged feed cost parameters is surprising. These results suggest that baconer production is more sensitive to feed costs when pigs are at porker weight than it is to feed costs when mating decisions are made. Although no documented a priori evidence is available on the impact of the relative attractiveness of porker production to "specialist" bacon producers it is difficult to believe

8.4.2 Production of Bacon Weight Pigs in the South Island

The specification of this equation is also very similar to the generalised specification discussed above. Again supply lags of between five and seven quarters were tested and the seven quarter lag gave best results. The original specification included 'average skim-milk production' and 'real wage' variables on a similar basis as the North Island equation above. However, neither of these variables were significant and were therefore rejected. Therefore, South Island bacon production is specified to be a function of:

- (a) Factors determining the relative profitability of pig production in the South Island lagged seven quarters. These factors are the farm price of pigs, the cost of feed and the change in the farm price of pigs. As these variables determine South Island bacon producers level of matings we would expect the parameters associated with the farm price and the change in farm price of pigs variables to be positive and the feed cost parameter to be negative.
- (b) Factors determining the relative profitability of different marketing weights for live pigs. These are represented by the real farm price of baconers/porkers ratio and the real feed cost lagged one quarter. We would expect the parameters associated with these variables to be positive and negative respectively.
- (c) Factors determining the relative profitability of pig production in the current period. These factors were represented by the real price of baconer pigs/real cost of feed ratio which we would expect to be positively related to production in the current period.

- (d) Factors representing the influence of dairy by-product feeding on production. These were represented by the current and lagged values of the 'quantity of skim milk' variable. We would expect both parameters to be positive and the current value to have a parameter larger than the lagged value (i.e. because current supplies of skim-milk will tend to increase the average weight of baconer pigs produced).
- (e) The lagged dependent variable.
- (f) The four dummy variables used in the North Island baconer equation.

This specification was estimated using quarterly observations for the period 1970 (fourth quarter) to 1979 (second quarter). Because the equation includes a lagged dependent variable (and therefore the Durbin-Watson test is not applicable) the equation was estimated using 2SPC (CORC) and \hat{p} tested for significance. As this statistic was significant at the 10 percent level the 2SPC (CORC) equation was used and yielded the following result:

$$\begin{aligned}
 \text{PBS} = & 472.12 + 6.77 \text{ L7FPBS} - 1.79 \text{ L7FEDS} + 1.396 \text{ L7CFBS} \\
 & \quad (1.5) \quad (1.22) \quad (3.27) \\
 & + 1,290.5 \text{ L1PBRS} - 5.899 \text{ L1FEDS} - 0.0059 \text{ L1SKS} \\
 & \quad (362.9) \quad (1.45) \quad (0.105) \\
 & + 21.04 \text{ DBFRS} + 0.488 \text{ SKIMS} - 1,278.76 \text{ D2OQ} \\
 & \quad (224.3) \quad (0.116) \quad (185.32) \\
 & + 501.59 \text{ D2} + 223.76 \text{ D3} - 274.82 \text{ D4} + 0.345 \text{ L1PBS} \\
 & \quad (91.39) \quad (118.00) \quad (126.17) \quad (0.112)
 \end{aligned}$$

$R^2 = 0.975$, $\hat{p} = -0.261$, figures in brackets are standard errors

where:

- PBS = Production of bacon weight pigs in the South Island (tonnes)
- L7FPBS = Real farm price of baconers in the South Island lagged seven quarters
- L7FEDS = Real cost of feed in the South Island lagged seven quarters
- L7CFBS = Change in the real farm price baconers in South Island lagged seven quarters
- L1PBRs = Ratio of farm price of baconers/porkers in South Island lagged one quarter
- L1FEDS = Real cost of feed in the South Island lagged one quarter
- L1SKS = Supply of skim-milk in the South Island lagged one quarter
- DBFRS = Ratio of farm price of baconers/feed costs in South Island
- SKIMS = Supply of skim-milk for change in grading classification
- D20Q = Dummy variable for change in grading classification
- Di = Seasonal dummies ($i = 2, 3, 4$)
- L1PBS = Lagged dependent variable

All the parameters in the equation have the correct sign except L1SKS which is not significantly different from zero. The explanatory variables explain more than 97 percent of the variation in the dependent variable. All of the parameter estimates are significantly different from zero at the 10 percent level except L7CFBS, L1SKS and DBFRS. An examination of the correlation matrix indicates that multicollinearity is only likely to effect L1SKS (it has a correlation coefficient of 0.62 with D20Q).

These results suggest that the current profitability of baconer production does not effect current production in the South Island and that South Island producers have naive rather than extrapolative price expectations. This is consistent with the seven quarter lag between price changes and production responses which implies that either South Island producers are considerably less efficient at producing pigs (and therefore have longer management lags in production) or South Island producers require longer periods to react to price changes. If the latter is true then changes in the productivity of production are unlikely to have a significant effect on production in

the same quarter (because a large number of producers will not have decided to change their production).

The relative sizes of the elasticities shown in Table 8-5 indicate a considerable sensitivity of baconer production to the relative profitability of porker production. The production of bacon weight pigs appears to be more sensitive to the relative profitability of porker production than it is to the profitability of baconer production at time of mating. The elasticities associated with changes in L7FPBS and L7FEDS appear a little low in comparison with comparable elasticities derived from the North Island equation and the elasticities reported by Richardson and O'Connor for Australia (although the price elasticity is similar to that reported by McClements for Northern Ireland). Given the structural characteristics of production in the South Island we would expect South Island bacon production to be considerably more sensitive to feed cost fluctuations than North Island production.

Finally, the parameter associated with the lagged dependent variable is significant at the 5 percent level and implies a coefficient of adjustment of 0.655 (i.e. that in any one quarter, producers only make 65 percent of the adjustment in the level of production that they desire to make).

8.4.3 Production of Pork Weight Pigs in the North Island

The specification of the porker supply equations for each island has to be consistent with the baconer supply equation for the same island and has to reflect the dual influence of "specialist" porker producers as well as the residual and speculative nature of pork production emanating from "specialist" baconer producers. "Specialist" porker producers are assumed to vary the size of their breeding herd in response to changes in the farm price for pork and

bacon lagged four quarters. This implies the same lag structure for both porker and baconer production in the North Island.

The inclusion of North Island baconer production as an explanatory variable reflects the residual nature of porker production. We would expect the parameter associated with this variable to be positive (i.e. when baconer production is high there will be a larger number of potentially bacon weight pigs slaughtered at pork weights as baconer producers attempt to keep pen utilisation high).

The speculative motives of both types of producers are captured by the inclusion of current price and cost variables. The production of pork weight pigs will increase as the farm price of porkers increases and the ratio of the farm price of baconers/cost of feed decreases.

Both current and lagged values of the 'supply of skim-milk' variable were included to account for the effect of dairy by-product supply on porker production. We would expect the lagged value to have a higher parameter than the current value (which could, on a priori grounds, be either positive or negative). As the current supply of skim-milk increases farmers will decide to take pigs to heavier weights. This will increase the supply of porker pigs (expressed in tonnes) only if the increase in the average weight of porker pigs is not offset by a decrease in the total number of porker pigs (as increased liveweight pushes pigs into the baconer category).

The four dummies included in the baconer equations are also included in this equation along with the lagged dependent variable.

This specification was estimated using quarterly data for the period 1970 (first quarter) to 1979 (second quarter). Because this equation includes a lagged dependent variable it was initially estimated using 2SPC (CORC). The estimate

for p was tested and found significant at the 1 percent level so the 2SPC (CORC) equation was retained. This estimation yielded the following results:

$$\begin{aligned}
 \text{PPN} = & -1,420.32 + 1.231 \text{ L4FPPN} - 4.078 \text{ L4FPBN} \\
 & \quad (3.12) \quad (3.057) \\
 & + 0.35 \text{ PBN} - 689.2 \text{ DBFRN} + 5.815 \text{ DFPPN} \\
 & \quad (0.08) \quad (477.8) \quad (4.12) \\
 & + 0.049 \text{ L1SKN} + 0.03 \text{ SKIMN} + 254.77 \text{ D2OQ} \\
 & \quad (0.022) \quad (0.02) \quad (158.40) \\
 & + 726.78 \text{ D2} + 623.45 \text{ D3} + 593.42 \text{ D4} + 0.7647 \text{ L1PPN} \\
 & \quad (140.60) \quad (115.07) \quad (134.42) \quad (0.1238)
 \end{aligned}$$

$$R^2 = 0.95, \hat{p} = -0.536 (0.138), \text{ standard errors are in brackets}$$

where:

- PPN = Production of pork weight pigs in the North Island (tonnes)
- L4FPPN = Real farm price porkers in North Island lagged four quarters
- L4FPBN = Real farm price baconers in the North Island lagged four quarters
- PBN = Production of baconers in the North Island
- DBFRN = Real farm price baconers/Real feed costs in North Island
- DFPPN = Real farm price in the North Island
- L1SKN = Skim-milk supply on North Island lagged one quarter
- SKIMN = Skim-milk supply in North Island
- D2OQ = Dummy variable for change in grading classification
- Di = Seasonal dummies (i = 2,3,4)
- L1PPN = Lagged dependent variable.

All the estimated parameters have the expected sign and the explanatory variables explain 95 percent of the variation in the dependent variable. Although all the variables except the lagged porker price have standard errors smaller than the parameter estimate, DBFRN, DFPPN, L4FFBN and SKIMN are all insignificant at the 10 percent level. However, multicollinearity is likely to have had an influence on some of these standard errors. The lagged pork and bacon prices are highly correlated

($R = 0.83$) although the parameter estimates for these variables are reasonably stable (see Table 8-2). The current farm price of pork is correlated with its lagged value ($R = 0.59$) although its parameter also appears to be reasonably stable. The baconer price/feed cost ratio is correlated with current levels of baconer production ($R = -0.51$) although this parameter also appears to be stable. The lagged dependent variable has a large parameter estimate associated with it which implies that porker production adjusts slowly towards the "desired" level. This is difficult to accept. The relatively small size of the porker market should allow for at least as speedy an adjustment of porker production to desired levels as baconer production.

The relative size of the elasticities reported in Table 8-3 indicates that porker production is dominated by the "residual" production of porkers by "specialist" baconer producers (a 1 percent increase in baconer production results in a 0.6 percent increase in porker production in the same period). The influence of the relative profitability of baconer production appears to be weak (especially when compared to the degree of substitutability implied by the elasticities derived from the baconer equation). This point is taken up in the next section when parameters are checked for consistency across equations.

8.4.4 Production of Pork Weight Pigs in the South Island

Because of the relatively small size of the porker market in the South Island and the greater homogeneity of production techniques (i.e. the greater predominance of grain feeding), a slightly different approach was used in specifying the South Island porker supply equation. Porker production in the South Island is dominated by baconer production because there is only a limited number of "specialist" porker producers.

Therefore supply is primarily a function of the number of sows mated for baconer production ("residual" supply will be directly related to the level of sows mated in some previous period) and the proportion of "potential baconers" diverted into the porker market. The influence of specialist porker producers is represented although this isn't particularly significant.

The South Island baconer production equation implies that the number of sows mated is a function of the real price of baconer pigs and real feed costs lagged seven quarters (the first difference parameter was not significantly different from zero). This is represented in the South Island porker equation by the ratio of real baconer farm prices/real feed costs lagged seven quarters.

The influence of "specialist" pork producers (who may add to the number of sows mated within the seven quarter lag) is reflected by the inclusion of the real farm price of porkers and of feed costs both lagged three quarters. It is difficult to speculate how long this lag should be on a priori grounds. Because of the relatively small size of the porker market in the South Island; "specialist" porker producers are able to purchase breeding stock to increase herd numbers in aggregate. There are also a number of producers who buy weaner pigs and produce porker pigs (i.e. their enterprise has no breeding herd). The lag applicable to these types of producers as a group could vary between six quarters and two quarters. The three quarter lag yielded the best result. Given the rationale for including these variables we would expect the lagged porker price to have a positive coefficient and the lagged feed price a negative coefficient.

The final decision on which weight to market pigs occurs in the quarter live pigs reach porker weight. Three variables will affect this decision; the price of baconer pigs, the cost of feed and the availability of skim-milk. We would expect the parameters associated with the price of baconers

and the cost of feed to be negative and positive respectively (e.g. increased baconer prices and reduced feed costs increase the benefits and reduce the costs of taking pigs onto bacon weight). Again it is difficult, a priori, to determine the sign of the parameter associated with the current supply of skim-milk variable. However, it is more likely that this parameter will be negative in the South Island (where baconer producers are likely to use more skim-milk to take more pigs through to bacon weights) compared with the North Island (where porker producers are likely to use the same situation to increase the average weight of porker pigs). The lagged value of skim-milk supply is also used as an explanatory variable and should be positively related to porker supply (i.e. declining supplies of skim-milk available for growing (rather than finishing pigs) should act to depress porker production).

The four dummies included in the baconer equations are also included in this equation along with the lagged dependent variable.

This specification was estimated using quarterly data for the period 1970 (third quarter) to 1979 (second quarter). Because this equation includes a lagged dependent variable it was initially estimated using 2SPC (CORC). The estimate for p was tested and found insignificant at the 20 percent level (its t ratio was only 0.3). Therefore a 2SPC estimate was used and yielded the following result:

$$\text{PPS} = 500.98 + 213.91 \text{ L7BFRS} + 0.3817 \text{ L3FPFS} - 1.64 \text{ L3FEDS}$$

(98.0) (0.57) (0.49)

$$+ 0.063 \text{ L1SKS} - 0.065 \text{ SKIMS} + 0.205 \text{ DFEEFS} - 0.627 \text{ DFPBS}$$

(0.04) (0.038) (0.503) (0.620)

$$+ 640.5 \text{ D2OQ} + 44.18 \text{ D2} - 8.846 \text{ D3} + 204.25 \text{ D4} + 0.134 \text{ L1PPS}$$

(84.1) (37.90) (49.2) (46.82) (0.102)

$$R^2 = 0.984, \text{ DW} = 1.79, \text{ figures in brackets are standard errors.}$$

where:

PPS = Production of pork weight pigs in the South Island (tonnes)
 L7BFRS = Real farm price baconers/real feed cost ratio lagged seven quarters
 L3FPPS = Real farm price porker pigs in the South Island lagged three quarters
 L3FEDS = Real cost of feed in the South Island lagged three quarters
 L2SKS = Supply of skim-milk in the South Island lagged one quarter
 SKIMS = Supply of skim-milk in the South Island
 DPEEDS = Real cost of feed in the South Island
 DFPBS = Real price of baconer pigs in the South Island
 L1PPS = Lagged dependent variable

All the parameters in the equation have the expected sign and together the explanatory variables explain 98 percent of the variation in the dependent variable. Three variables (L3FPPS, D2 and DFEEDS) have parameters smaller than the parameter standard error and the L1SKS, DFPBS, D2 AND L1PPS Parameters are not significantly different from zero at the 10 percent level. Multicollinearity may have had some effect on the error values associated with these values, however (apart from L1PPS) none of the coefficients in the correlation matrix exceed 0.63 and the figures reported in Table 8-4 indicate that none of these parameters are unstable. The correlation between L1PPS and D20Q is very high ($R = 0.93$) and this is likely to have influenced the standard error associated with both variables parameters (although both parameters appear stable).

An examination of the elasticities in Table 8-5 indicates that porker production in the South Island is relatively insensitive to changes in the explanatory variables. The total number of sows mated (itself a function of L7BFRS) and the relative profitability of baconer production in the current period are important influences on porker production. However, the third quarter lagged response of production to the relative profitability of porker production is

unacceptably asymmetric (being far more sensitive to feed costs than farm prices for porker pigs). The low value for the lagged dependent variable indicates that pork production adjusts rapidly to desired levels (the coefficient of adjustment is 0.866) although collinearity with D20Q has probably affected this estimate.

8.4.5 Production of Choppers in the North and South Island

As chopper pigs are primarily cull breeding stock, the supply of chopper pigs will be directly related to changes in herd size. However, farmers can alter the size of their breeding herd by either changing the number of breeding stock killed or the number of gilts entering the breeding herd.

Unfortunately no time series are available which describe quarterly movements in either the level of the breeding herd or the number of gilts retained by producers. This section describes the derivation of the chopper supply functions from a definition of the sow kill to a form that is able to be estimated with the data available.

The change in the level of the breeding herd in any one quarter will be equal to the number of gilts entering the herd minus the number of sows slaughtered:

$$\Delta H_t = GR_t - SK_t \quad (8.4:1)$$

where:

$$\begin{aligned} \Delta H_t &= \text{change in breeding herd over the quarter} \\ GR_t &= \text{gilt retention during the quarter} \\ SK_t &= \text{sow kill during the quarter} \end{aligned}$$

Lack of data describing the quarterly change in the breeding level or the numbers of gilts entering the breeding herd has forced the "one stage" formulation of the baconer and porker production equations above rather than the "two stage" approach used in overseas studies. The production

equations are a direct function of economic factors which determine the size of the sow herd rather than a function of the size of the sow herd which is then a direct function of economic factors. This lack of data also complicates the specification of a chopper meat production equation. Chopper meat supply equations were derived using the identity (8.4.1) and substituting functional relationships explaining ΔH_t and GR_t :

$$SK_t = GR_t - \Delta H_t$$

$$GR_t = a_0 - a_1 DFPB_{t-(5-k)} - a_2 DFEED_{t-(5-k)} + a_3 \Delta H_t + a_4 LKB/F \quad (8.4.2)$$

where:

- DFPB = Real farm price of baconers
- DFEED = Real cost of feed
- LKB/F = Ratio of the real farm price baconers/real cost of feed lagged k quarters
- k = k quarter lag (where k=5 in the North and 7 in the South Island).

This equation states that the number of gilts retained will be a function of the change in the sow herd and factors that determine how much of this change will be split between changing the number of gilts retained and changing the number of sows killed. More gilts will be retained if the number of bacon weight pigs available to be selected from is large (i.e. positively related to LKB/F), and if the farm price of bacon weight pigs and feed prices are low. Low baconer prices reduce the opportunity cost of retaining pigs for breeding purposes and low feed prices reduce the cost of taking bacon weight pigs up to breeding weight.

$$\Delta H_t = b_0 + b_1 DFPB_{t-(5-k)} - b_2 DFEED_{t-(5-k)} - b_3 TIME \quad (8.4.3)$$

where:

- $\Delta DFPB$ = change in the real farm price of baconers
- $\Delta DFEED$ = change in the real feed costs
- TIME = time (where the fourth quarter 1968 = 1)
- k = the lag between the factors that determine production capacity in the baconer equations and 5 (i.e. the shortest lag acceptable on biological/management grounds). Therefore in the North Island $5-k = 5-5 = 0$ and in the South Island $5-k = 5-7 = -2$.

This equation states that the herd size will increase if the profitability of production increases but that, for a given level of profitability the corresponding change in herd size will decline with time due to increases in productivity. Chapter Two (section 2.3.2) noted the increase in the number of pigs marketed per sow per year between 1957-66 and 1966-75. The time variable acts as a proxy for the technological factors underlying this increase in productivity and implies that this increase occurs at a constant pace.

When (8.4.2) and (8.4.3) are substituted back into (8.4.1) we have an expression for the number of sows killed in any one quarter.

$$\begin{aligned} SK_t &= GR_t - \Delta H_t \quad (\text{for simplicity } K \text{ is set equal to } 5) \\ &= a_0 - a_1 DFPB_t - a_2 DFEED_t + a_3 \Delta H_t + a_4 L5B/F - \Delta H_t \\ &= a_0 - a_1 DFPB_t - a_2 DFEED_t + a_4 L5B/F + (a_3 - 1) \Delta H_t \end{aligned}$$

Given that $0 < a_3 < 1$ then $(a_3 - 1)$ will be negative so:

$$SK_t = a_0 - a_1 DFPB_t - a_2 DFEED_t + a_4 L5B/F - a_5 \Delta H_t$$

Substitute (8.4.3):

$$\begin{aligned} SK_t &= a_0 - a_1 DFPB_t - a_2 DFEED_t + a_4 L5B/F - a_5 (b_0 + b_1 \Delta DFPB_t \\ &\quad - b_2 \Delta DFEED_t - b_3 TIME) \\ &= a_0 - a_5 b_0 - a_1 DFPB_t - a_2 DFEED_t + a_4 L5B/F - a_5 b_1 \Delta DFPB_t \\ &\quad + a_5 b_2 \Delta DFEED_t + a_5 b_3 TIME \\ &= a_0 - a_1 DFPB_t - a_2 DFEED_t + a_3 L5B/F - a_4 \Delta DFPB_t \\ &\quad + a_5 \Delta DFEED_t + a_6 TIME \end{aligned} \tag{8.4.4}$$

Note : when $K = 7$ equation (8.4.4) is changed to:

$$\begin{aligned} SK_t &= a_0 - a_1 DFPB_{t-2} - a_2 DFEED_{t-2} \\ &\quad + a_3 L7B/F - a_4 \Delta DFPB_{t-2} \\ &\quad + a_5 \Delta DFEED_{t-2} + a_6 TIME \end{aligned}$$

Equation (8.4.4) is the expression for the number of sows killed and assumes complete adjustment to desired levels in any one quarter. In order to complete the specification for the weight of chopper meat slaughtered in any one quarter the current and lagged values for skim-milk supply were added to (8.4.4) on the assumption that farmers will use some of their cheap skim-milk supplies to increase the slaughter weight of cull stock. Finally a lagged dependent variable was added to reflect partial adjustment in any one quarter.

This specification was estimated for the North Island using quarterly data for the period 1979 (first quarter) to 1979 (second quarter). Because this equation includes a lagged dependent variable it was initially estimated using 2SPC (CORC). The estimate for p was tested and found significant at the 1 percent level. Therefore the 2SPC (CORC) estimate was used and yielded the following result:

$$\begin{aligned}
 PCN = & 287.44 + 262.0 \text{ L5BFRN} - 0.964 \text{ DFPBN} - 1.656 \text{ DFEEDN} \\
 & \quad (190.5) \quad (1.11) \quad (1.21) \\
 & + 4.85 \text{ TIME} - 270.0 \text{ CHBFRN} + 0.0305 \text{ L1SKN} \\
 & \quad (3.46) \quad (205.2) \quad (0.01) \\
 & + 0.022 \text{ SKIMN} + 89.0 \text{ D2} - 7.14 \text{ D3} - 17.05 \text{ D4} + 0.175 \text{ L1PCN} \\
 & \quad (0.009) \quad (29.9) \quad (41.8) \quad (31.0) \quad (0.178)
 \end{aligned}$$

$$R^2 = 0.81, \hat{p} = 0.57, \text{ figures in brackets are standard errors}$$

where:

- PCN = Production of chopper weight pigs in the North Island (tonnes)
- L5BFRN = Real price baconer pigs/real feed costs lagged five quarters
- DFPBN = Real price of baconer pigs in the North Island
- DFEEDN = Real cost of feed in the North Island
- TIME = Time (with fourth quarter 1968 = 1)
- CHBFRN = Change in the farm price baconer/feed cost ratio (North Island)
- L1SKN = Skim milk production in the North Island lagged one quarter
- SKIMN = Skim milk production in the North Island
- D_i = Seasonal dummy for quarter i ($i = 1, 3, 4$)
- L1PCN = Lagged dependent variable

The generalised specification was also estimated for the South Island. However the South Island data had one quarter with a low kill figure followed by another with an exceptionally high kill figure (the second and third quarters of 1977 respectively). This was very difficult to explain with the specification outlined and may well have been due to extraordinary factors. (e.g. if farmers were unable to get choppers killed in the second quarter 1977). Therefore it was decided to omit these two observations from the analysis. Therefore the specification was estimated from 1970 (third quarter) to 1979 (second quarter) with the second and third quarters of 1977 omitted. As the parameters associated with the two skim-milk variables and the lagged dependent variable were highly insignificant, these variables were omitted from the analysis. The equation was then estimated using 2SPC to yield the following result:

$$\begin{aligned}
 \text{PCS} = & 182.17 + 119.91 \text{ L7BFRS} - 0.371 \text{ L2FPBS} - 94.45 \text{ L2CBFS} \\
 & \quad (22.76) \quad (0.121) \quad (30.96) \\
 & - 0.544 \text{ L2FEDS} + 0.32 \text{ TIME} + 23.3 \text{ D2} - 1.2 \text{ D3} - 23.5 \text{ D4} \\
 & \quad (0.164) \quad (0.24) \quad (6.9) \quad (6.9) \quad (6.6)
 \end{aligned}$$

$R^2=0.82$, $DW = 1.76$, standard errors in brackets.

All the parameters in both equations have the expected sign and together the explanatory variables explain 81 percent and 82 percent of the variation in North and South Island equations respectively. In the South Island equation all variables except TIME and D2 are significant at the 1 percent level. In the North Island equations all variables except DFPBN, L1PCN, D3 and D4 have parameter estimates larger than the associated standard errors but only the two skim-milk supply variables and the second quarter dummy are significantly different from zero at the 10 percent level.

An examination of the correlation matrix reveals a very low level of correlation between most explanatory variables in the North Island equation. However, time is correlated

with skim-milk supply ($R = 0.72$ for both current and lagged values) and the lagged baconer price/feed ratio is correlated with current real feed costs ($R = 0.57$). Given the strong a priori evidence that sow productivity has increased with the move to grain feeding, the TIME variable cannot be rejected because of the standard error associated with its parameter. It is probable that the two skim-milk variables are acting as a proxy for this productivity increase. Finally, given the very low t-ratio for the lagged dependent variable the hypothesis that North Island sow kill only partially adjusts to its desired level in any one quarter must be rejected.

The elasticities derived for the South Island equation are presented in Table 8-5 and indicate that factors that affect herd size and gilt retention are of similar importance in determining sow kill. It would also appear from these results that the choice between retaining gilts or old sows is more strongly influenced by the costs of bringing bacon weight pigs up to breeding weight than the immediate loss of revenue from retaining these gilts. The elasticities for the North Island equation presented in Table 8-3 supports this conclusion. In both cases the value of the feed cost elasticity is approximately twice the size of the baconer price elasticity.

8.5 Evaluation of the Stability of the Parameter Estimates and their Regional Consistency

This section applies the usual test of the stability of parameter estimates to changes in sample size as well as discussing the internal consistency of each of the two sets of three equations that describe total supply in each island. The discussion in section 8.4 above evaluated the parameter estimates for each equation individually. However, the hypothesised relationship between porker and baconer production allows us to test these parameters for consistency

with respect to parameters in the other equations. Of special interest in this regard is the relationship between baconer and porker production in each island.

8.5.1 Parameter Stability of Consistency in the North Island Equations

The stability of the parameter estimates in the North Island equations was tested using the procedure established in previous chapters. Five observations were dropped off the end of the sample period, the equations were re-estimated and the changes in the coefficients were tested for significance using an F statistic. The results are presented in Table 8-2. Because the calculated F values are less than the critical value (at the 5 percent level of significance) for all three equations we accept that the structural coefficients in all of these equations are stable.

The important elasticities derived from the North Island supply equations are shown in Table 8-3. A sustained 1 percent increase in the baconer price will result in a 0.712 (i.e. $0.867 - 0.155$) percent increase in baconer production (or 29.7 tonnes at average quantities). However, this increase will also affect porker production.

A sustained 1 percent increase in baconer prices will reduce porker production by 1.98 percent (i.e. $1.05 + 0.93$) due to the diversionary price effect but increase porker production by 1.85 percent (i.e. $0.712 * 2.26$) due to the "residual" effect. This results in a net reduction of 0.13 percent in porker production (or 3.1 tonnes at average quantities). This 3.1 tonnes reduction in porker production converts into 4.89 tonnes of baconer production (i.e. $3.1 * (\text{average weight baconer carcass} / \text{average weight porker carcass}) = 4.89$). Therefore, a sustained 1 percent increase in baconer prices will result in a 0.712 percent increase in baconer production (of which 16 percent is diverted from porker production) and a 0.13 percent reduction in porker production.

Table 8-2

Testing the Structural Stability of the
North Island Pig - Meat Supply Equations

n	BACONER		PORKER		CHOPPER	
	38	33	37	32	37	32
Constant	6,879.7	7,316.64	-1,420.3	-1,586.5	287.4	304.9
L5CFBN	6.80	7.42				
L5FPBN	25.04	25.14				
L5FEDN	-4.44	-3.35				
L5WGE	-2.58	-3.55				
L5ASN	0.759	0.710				
L1FPPN	-33.31	-37.17				
L1FEDN	-9.50	-9.25				
DWAGE	3.34	3.817				
ASKIMN	-1.29	-1.307				
L4PPN			1.232	1.54		
L4FPBN			-4.08	-4.98		
DBFRN			-689.2	-679.8		
DFPPN			5.815	6.62		
L5BFRN					262.0	259.6
FEEDN					-1.656	-1.67
CHBERN					-270.0	-276.7
TIME					4.848	5.13
DFPBN	-4.646	-1.948			-0.964	-1.14
L1SKN	0.397	0.426	0.049	0.045	0.03	0.03
SKIMN			0.031	0.039	0.02	0.02
D2OQ	-1,253.4	-1,241.6	254.77	227.35		
D2	507.7	456.9	726.78	804.09	89.0	95.7
D3	112.2	268.5	623.45	655.59	-7.14	9.5
D4	451.6	554.3	593.42	598.3	-17.0	-4.79
L1PPN			0.765	0.785		
L1PCN					0.175	0.163
PBN			0.35	0.37		
\hat{p}			-0.536	-0.514	0.578	0.60
\hat{e}^2	2,905,650.0	2,310,330.0	594,338.0	465,573.0	83,345.0	78,696.0
F*	0.876		1.05		0.23	

Table 8-3

Important Elasticities Derived from the
North Island Supply Equations

Independent Variable	Dependent Variable				
	Baconer	Porker		Chopper	
		Short Run	Long Run	Short Run	Long Run
L5FPBN	0.867 ¹				
L5FEDN	-0.197				
L5WGE	-0.614				
L5ASN	0.573				
L1FPPN	-0.976				
L1FEDN	-0.422				
DWAGE	0.812				
ASKIMN	-0.708				
L4PPPN		0.06	0.27		
L4FPBN		-0.247	-1.05		
DBFRN		-0.219	-0.932		
DFPPN		0.296	1.261		
L5BFRN				0.576	0.698
FEEDN				-0.86	-1.04
DFPBN	-0.155			-0.38	-0.46
L1SKN	0.219	0.05	0.20	0.19	0.23
SKIMN		0.02	0.108	0.12	0.15
PBN		0.613	2.61		

1. This excludes the influence of the 'change in farm price' variable. If the farm price was to increase 1% and the influence of the 'change in farm price' variable is included then the elasticity increases to 1.1.
2. The formula for the calculation of the long run estimates is: $ELR = ESR/(1-b)$ where ELR is the long run elasticity, ESR is the short run elasticity, and b is the regression coefficient on the lagged dependent variable.

Table 8-4

Testing the Structural Stability of the
South Island Pig - Meat Supply Equations

n	BACONER		PORKER		CHOPPER	
	34	30	36	31	34	29
Constant	472.1	562.9	500.98	550.35	182.17	190.96
L7FPBS	6.77	5.13				
L7FEDS	-1.79	-1.88				
L7CFBS	1.39	-1.08				
L1PBRs	1,290.5	1,103.1				
L1FEDS	-5.80	-5.36				
DBFRS	21.04	99.0				
L1SKS	-0.006	0.056	0.063	0.050		
SKIMS	0.488	0.487	-0.065	-0.074		
L7BFRS			213.9	77.4	119.9	62.84
L3FPBS			0.382	0.618		
L3FEDS			-1.644	-1.52		
DFEEDS			0.206	0.52		
DFPBS			-0.627	-0.811		
L2FPBS					-0.371	-0.343
L2CBFS					-94.45	-84.21
L2FEDS					-0.544	-0.35
TIME					0.320	0.36
D20Q	-1,278.7	-1,268.22	640.5	622.1		
D2	501.6	473.75	44.17	38.7	23.30	19.34
D3	223.7	251.36	-8.84	-45.7	-1.20	-5.06
D4	-274.8	-227.75	204.75	190.8	-23.55	-22.77
L1PBS	0.345	0.414				
L1PPS			0.134	0.131		
\hat{p}	-0.26	-0.21				
e^2	360,770.0	254,664.0	72,030.0	57,632.0	4,931.0	2,577.0
F	1.11		0.899		3.65	

Table 8-5

Important Elasticities Derived from the
South Island Supply Equations

Independent Variable	Dependent Variable				
	Baconer		Porker		Chopper
	Short Run	Long Run	Short Run	Long Run	
L7FPBS	0.438	0.669			
L7FEDS	-0.143	-0.219			
L1PBRS	0.619	0.945			
L1FEDS	-0.464	-0.708			
DBFRS	0.007	0.01			
L1SKS	-0.002	-0.003	0.0524	0.06	
SKIMS	0.142	0.217	-0.0523	0.06	
L7BFRS			0.219	0.254	0.69
L3FPPS			0.06	0.07	
L3FEDS			-0.36	-0.41	
DFEEDS			0.04	0.046	
DFPBS			-0.107	-0.124	
L2FPBS					-0.35
L2FEDS					-0.69
L2BFRS ¹					-0.54

1. Real farm price of baconer pigs/real feed costs in the South Island. Calculated using the average value of the ratio and the ratios first difference parameter in the chopper supply equation.

Unfortunately a 1 percent sustained increase in the farm price for porkers does not imply such a similarly credible response. A 1 percent sustained increase in the porker price will result in a 0.976 percent decrease in baconer production which implies a 1.08 percent increase in pork production as a result of live pigs being diverted from baconer to porker slaughter weights. This is about 70 percent of the total increase in porker production implied by a 1 percent sustained increase in porker price. However, the initial reduction in the supply of baconer pigs reduces porker production by a further 2.5 percent (i.e. 0.97×2.61) because the "residual" supply declines. Therefore, the net result of a sustained 1 percent increase in porker price is a reduction in both baconer and porker production of 0.97 percent (i.e. $-2.5 + 1.53$ for the effect on porker production). This confirms our earlier suspicion that the parameter attached to the lagged farm price for porkers in the baconer supply equation is too large and is likely to have been affected by the collinearity between this variable and the current farm price for baconers.

8.5.2 Parameter Stability and Consistency in the South Island Equations

The stability of the parameter estimates in the South Island equations was tested using the same procedure applied to the North Island equations. The results are presented in Table 8-4. The calculated F values for all equations are less than the critical value for F at the 1 percent level of significance. However, the calculated F value for the chopper equation exceeds the critical F value at the 5 percent level (the calculated F value is 3.65 and the critical value is 3.48 at the 5 percent level of significance). Although all of these parameter estimates can be accepted as being reasonably stable, the parameters in the chopper equation are least satisfactory in this regard.

The important elasticities derived from the South Island supply equations are shown in Table 8-5. A sustained 1 percent increase in the farm price for baconers will result

in a 1.61 percent increase in baconer production (i.e. $0.67 + 0.945$) and a 0.13 percent increase in porker production (i.e. the "residual" effect is greater than the diversionary effect). However, the diversionary effect implied by the LIPBRS elasticity and the DFPBS elasticity are not entirely compatible. A 1 percent increase in the farm price of baconers will result in a 0.945 percent increase in bacon production which, if it all came from diverted porker production, would imply a decrease in pork production of 1.6 percent (at average values) rather than the 0.124 percent implied by the DFPBS parameter in the porker equation.

The lack of a significant current porker price in the porker supply equation is an important weakness in the attempt to adequately define the relationship between porker and baconer production in the South Island. A sustained 1 percent increase in the farm price for porkers implies a 0.945 percent decrease in baconer production but only a 0.07 percent increase in porker production.

8.6 Conclusion

This chapter has discussed the specification, estimation and evaluation of the six production equations in the New Zealand pig-meat model. The equations are specified to represent the major production decisions taken by farmers. These specifications are consistent (with respect to both the determinants of these decisions and the lags involved in the production process) for each island.

The estimated equations are sensitive to pig-meat prices, feed costs, the supply of dairy by-product and real wages. They illustrate the different structures of production in each island. Production in the North Island is more sensitive to the supply of dairy by-products and less sensitive to feed costs. Baconer production is more sensitive to changes in

the profitability of porker production in the North Island which reflects the greater importance of porker production as a proportion of total production in this island.

In general, the elasticities derived from these equations are of a credible size (and bear a credible relationship to one another) within each equation. For example, the lagged farm price (which determines the number of matings), has a higher elasticity in the baconer equations than the current farm price (which determines the number of baconer weight pigs retained for breeding purposes). However, the baconer and porker equations are not an entirely consistent description of supply in each island when taken together. This is an important problem which constrains the use of the model. For example, the model could not be used to analyse the effect of setting a differential in the farm price for each weight range. Further work is required to improve this aspect of the production equations.

CHAPTER NINE

THE IMPORT AND EXPORT EQUATIONS: SPECIFICATION, ESTIMATION AND EVALUATION

9 .1 Introduction

This chapter discusses the specification, estimation and evaluation of the equations used to describe the imports and exports of cured pig-meat in the New Zealand Pig-Meat Model. The first section discusses the important characteristics of the cured pig-meat import and export trade. The relative size of this trade, the source and destination of trade, the presence of trade restrictions and the determinants of this trade are all discussed. In the second and third sections, the specification and estimation of these two equations are discussed separately and the parameter estimates are evaluated. The fourth section briefly discusses the stability of these parameter estimates using the technique applied in previous chapters.

9 .2 Features of the Cured Pig-Meat Import and Export Trade

The discussion in Chapter Two noted that:

"Throughout the 1950s and early 1960s exports were a regular and important feature of the market whereas imports of pig-meat were insignificant. This situation changed in the mid 1970s when domestic demand started to exceed domestic supply. During the 1970s domestic demand averaged in excess of 100 percent of domestic production and the industry changed from being a net exporter to a net importer of pig-meat."¹

Throughout the 1970s the import and export of cured pig-meat has been both a very small and very volatile component of the domestic market. During this period the average quarterly

1. See Chapter 2.3.3, p. 27

export of cured products was only 0.2 percent of average quarterly total production (i.e. only 20 tonnes) and had a standard deviation virtually as large as this mean value. Since the fourth quarter of 1972 (when imports were established as a regular feature of the market), the average quarterly imports of cured products has been only 3.6 percent of total production (i.e. 367 tonnes) with the standard deviation of quarterly imports nearly equal to its mean value over this period.

Pig-meat imports were exempt from licensing on 1 July 1964 and appeared on the original schedule A of NAFTA which came into effect on 1 January 1966. Prior to 1978, the tariff on pig-meat imports was a normal rate of 27.5 percent, Canada 20 percent, with Australian imports free. The revised tariff introduced on 1 July 1978 reduced the normal rates to 20 percent and the Canadian rate to 10 percent and in May 1979 the Canadian rate on pork was further reduced to 5 percent. Canada, Australia and Ireland are the major sources of pig-meat imports, supplying 56 percent, 30 percent and 12 percent of total 1974/75 - 1978/79 imports respectively. Changes in import duties are unlikely to have been very important in practice because processors had duty remitted in 1974/75 when Canadian imports were substantial.

There are a large number of heterogeneous destinations for exports of cured products. In 1978/79, 15 countries imported cured New Zealand pig-meat; Barbados and France were the most important destinations accounting for just over half of the total exports for that year.² In 1977/78 and 1976/77 New Caledonia was the largest single buyer (taking about 65 percent of exports in 1977/78 and about 33 percent in 1976/77). In 1975/76 Fiji and "Trinidad and Tobago" were the largest single buyers yet they only accounted for just over 25 percent of total exports. Given the very small

2. Department of Statistics, External Trade Exports; Commodity by Country, Country by Commodity 1975/76 - 1978/79.

quantity of exports involved and the diversity of the export destinations, New Zealand exporters are likely to face perfectly elastic demand curves.

The import and export of cured pig-meat is controlled by domestic processors. These processors are assumed to change the level of imports or exports in response to domestic vis-avis foreign price levels. This response will be modified in four ways. Firstly, there will be lags associated with ordering, shipping, etc. which means that the arrival of imports and departure of exports will lag behind the price changes that prompted these imports or exports. Secondly, in part because of these delays, imports and exports are unlikely to adjust to desired levels in any particular quarter. For example, any large import order placed in quarter t may actually arrive over quarters $t+1$ and $t+2$. Thirdly, processors expectations concerning future domestic price levels are likely to be important because of the lags involved in receiving imports and arranging for the sale of exports. Finally, although supply and demand factors for imports and exports respectively are relatively unimportant (i.e. given the extremely small quantities involved it would be reasonable to assume that domestic processors face perfectly elastic foreign prices), seasonal factors may influence the demand for cured pig-meat in small (island) export markets.

9.3 Specification, Estimation and Evaluation of the Import Relationship

Given the factors discussed above, importers are assumed to face a perfectly elastic foreign supply curve and therefore desired imports are a function of the expected price margin between domestic and foreign prices.

$$M_t^* = a_0 + a_1 DP_t^* + a_2 FP_t^* \quad (9.1)$$

where:

M_t^* = desired demand for imports
 DP_t^* = expected domestic (farm) price
 FP_t^* = expected foreign (cif) price

Note: The farm price is the relevant domestic price because, from the importers' point of view, imports are a substitute source of supply.

If importers form extrapolative price expectations and if there is a 1 quarter lag between price changes and the arrival of imports then:

$$DP_t^* = b_0 + b_1 DFPB_{t-1} + b_2 (DFPB_{t-1} - DFPB_{t-2}) \quad (9.2)$$

$$FP_t^* = C_0 + C_1 FP_{t-1} + C_2 (FP_{t-1} - FP_{t-2}) \quad (9.3)$$

Finally assuming that the desired level of imports do not all arrive in the quarter following price changes:

$$M_t - M_{t-1} = \delta (M_t^* - M_{t-1}) \quad (9.4)$$

Substituting (9.1):

$$\begin{aligned} M_t &= \delta M_t^* + (1-\delta)M_{t-1} \\ &= \delta (a_0 + a_1 DP_t^* + a_2 FP_t^*) + (1-\delta)M_{t-1} \end{aligned}$$

Substituting (9.2) and (9.3):

$$\begin{aligned} M_t &= \delta a_0 + \delta a_1 (b_0 + b_1 DFPB_{t-1} + b_2 \Delta DFPB_{t-1}) \\ &\quad + \delta a_2 (C_0 + C_1 FP_{t-1} + C_2 \Delta FP_{t-1}) + (1-\delta)M_{t-1} \\ &= \delta a_0 + \delta a_1 b_0 + \delta a_2 C_0 + \delta a_1 b_1 DFPB_{t-1} + a_1 b_2 \Delta DFPB_{t-1} \\ &\quad + \delta a_2 C_1 FP_{t-1} + \delta a_2 C_2 \Delta FP_{t-1} + (1-\delta)M_{t-1} \\ &= \alpha_0 + \alpha_1 DFPB_{t-1} + \alpha_2 \Delta DFPB_{t-1} + \alpha_3 FP_{t-1} + \alpha_4 \Delta FP_{t-1} \\ &\quad + \alpha_5 M_{t-1} \end{aligned}$$

This specification was estimated using quarterly observations from 1973 (third quarter) to 1979 (second quarter). The period from 1968-1972 was excluded from the analysis because imports were insignificant over this period (i.e. only three values were positive). This period is excluded in an effort to adequately model the period in which imports were a regular feature of the market (i.e. on grounds of structural homogeneity). Given that there was no import trade prior to 1973, it is reasonable to assume that there were "institutional" barriers to this trade as well as economic factors influencing the desirability of trade. Without regular trade links, domestic processors did not have the prerequisite expertise for importing (i.e. there was a lack of "perfect" information). The cost of obtaining the necessary information (expertise) was considered to be prohibitive given processors' perceptions of the domestic market. However, increasing domestic prices have prompted processors to acquire the necessary expertise and therefore import levels are now sensitive to relative prices.

Given the presence of the lagged dependent variable this equation was initially estimated using 2SPC (CORC). The lagged first difference cif price variable was very insignificant so the extrapolative hypothesis was rejected for foreign price expectations behaviour. The estimate of p was significant at the 1 percent level so the 2SPC (CORC) estimate was used and yielded the following result:

$$\text{MPTS} = -12.58 + 2.92\text{L1FPB} + 15.79\text{L1CFPB} - 66.9\text{L1DMPT}$$

$$(2.62) \quad (3.65) \quad (55.4)$$

$$0.59\text{L1MPTS} - 17.98\text{D2} - 67.1\text{D3} - 289.1\text{D4}$$

$$(0.2) \quad (208) \quad (96.5) \quad (215.0)$$

$$R^2 = 0.786, \hat{p} = -0.61, \text{ figures in brackets are standard } (0.15) \text{ errors}$$

where:

$$\text{MPTS} = \text{Quantity of imports (tonnes)}$$

L1FPB	=	The real farm price for baconer pigs lagged one quarter
L1CFPB	=	The change in the real farm price for baconer pigs lagged one quarter
L1DMPT	=	The real cif price of imported pig-meat lagged one quarter
L1MPTS	=	Lagged dependent variable
Di	=	Dummy for quarter i (i=2,3,4)

Note: The farm price is the sum of regional prices weighted by the proportion of total production produced in each region.

All of the parameters have the expected sign and, altogether, the explanatory variables explain over 78 percent of the variation in the dependent variable. Although all of the parameters except D2 and D3 have standard errors smaller than the parameter value, only L1CFPB and L1MPTS are significantly different from zero at the 10 percent level. The standard error associated with the L1FPB variable could well be affected by multicollinearity. The correlation coefficient between L1FPB and L1MPTS is 0.83 and the parameter associated with L1FPB has nearly doubled as the sample size is reduced from 25 to 20 (see Table 9.3 however, the F test indicates that the parameter estimates in this equation are stable).

The important import elasticities are reported in Table 9.1 and indicate that imports are very sensitive to the level of farm prices and less sensitive to the cif import price. This could be an indication that processors use imports to keep the utilisation of processing plant high and, therefore, throughput reasonably stable. If this is the case the level of farm prices may be acting as a proxy for the level of production. We have assumed that high farm prices stimulate processors desire to find cheaper substitutes, however high farm prices are associated with low levels of farm production and, therefore, the relationship between farm prices and imports may partially reflect importers' desire to maintain throughput in the face of falling domestic production.

Given that a strong negative relationship between farm production and farm prices (in the same quarter) is likely to persist, this is not a serious problem when the model is used for forecasting.

Table 9.1

Import Elasticities

	<u>Short Run</u>	<u>Long Run</u>
L1FPB1	1.13	2.77
L1DMPT	-0.38	-0.93

1. If the short run elasticity is adjusted for the impact of L1CFPB it increases to 7.26 (i.e. a 1 percent increase in the farm price will result in a 7.26 percent increase in the level of imports in the following quarter at average prices and quantities).

9.4 Specification, Estimation and Evaluation of the Export Relationship

Given the factors discussed in section 9.1 above, exporters are assumed to face a perfectly elastic foreign demand curve, and, therefore, desired exports are also a function of expected relative prices. Trial estimations indicated that non-naïve expectations hypotheses had to be rejected so expected prices were assumed to be a function of actual lagged prices:

$$X_t = a_0 + a_1 DP_{t*} + a_2 FP_{t*} \quad (9.5)$$

$$DP_{t*} = b_0 + b_1 L1DRBC \quad (9.6)$$

$$FP_{t*} = c_0 + c_1 L1DXB \quad (9.7)$$

where:

- X_t = desired supply of cured product exports (tonnes).
 DP_t^* = expected domestic price of cured products
 FP_t^* = expected foreign price of cured products
 $L1DRBC$ = real retail price of bacon and ham lagged one quarter
 $L1DXB$ = real fob price of cured product exports lagged one quarter

Note: The retail price is the relevant domestic price because exports are a competitive form of demand (i.e. processors will decide how much product will be sold on local or export markets depending on relative prices).

Assuming that exporters cannot export all the cured pig-meat they wish to in any one quarter:

$$X_t - X_{t-1} = \delta(X_t^* - X_{t-1}) \quad (9.8)$$

Substituting (9.5):

$$\begin{aligned}
 X_t &= \delta X_t^* + (1-\delta)X_{t-1} \\
 &= \delta(a_0 + a_1 DP_t^* + a_2 FP_t^*) + (1-\delta)X_{t-1}
 \end{aligned}$$

Substituting (9.6) and (9.7):

$$\begin{aligned}
 X_t &= \delta a_0 + \delta a_1(b_0 + b_1 L1DRBC) + \delta a_2(c_0 + c_1 L1DXB) + (1-\delta)X_{t-1} \\
 &= \delta a_0 + \delta a_1 b_0 + \delta a_2 c_0 + \delta a_1 b_1 L1DRBC + \delta a_2 c_1 L1DXB + (1-\delta)X_{t-1} \\
 &= \alpha_0 + \alpha_1 L1DRBC + \alpha_2 L1DXB + \alpha_3 X_{t-1}
 \end{aligned}$$

This specification was estimated using quarterly data from 1971 (second quarter) to 1979 (second quarter). Because the seasonal pattern of supply over this period was significantly affected by dairy by-product fed meat, two additional seasonal dummies were added to allow seasonal intercepts to alter as

a consequence of this structural change. Given the presence of the lagged dependent variable this equation was initially estimated using 2SPC (CORC). The estimate of p was significant at the 5 percent level so the 2SPC (CORC) estimate was used and yielded the following result:

$$XPTB = -1.01 - 0.032L1DRBG + 5.86L1DXB + 0.33L1XPBT$$

(0.035) (3.62) (0.08)

$$+ 4.35D2 + 2.12D3 + 12.93D4 + 51.03D317$$

(5.0) (4.82) (5.94) (5.91)

$$+ 29.77D422$$

(6.52)

$$R^2 = 0.89, \hat{p} = -0.38, \text{ standard errors in brackets}$$

(0.15)

All of the parameters have the expected sign and, altogether, the explanatory variables explain over 89 percent of the variation in the independent variable. The standard error associated with the lagged retail price parameter could be affected by multicollinearity; it is positively correlated with the fob export price ($R = 0.63$) however its parameter appears relatively stable (see Table 9.3).

The important export elasticities are reported in Table 9.2 and indicate that exports are only slightly more sensitive

Table 9.2

Export Elasticities

	<u>Short Run</u>	<u>Long Run</u>
L1DRBC	-0.78	-1.16
L1DXB	0.92	1.38

to changes in the export price than the domestic retail price (although this result could be influenced by multicollinearity between these two variables).

The seasonal dummy variables indicate that there has been a significant change in the seasonal pattern of exports in the latter half of our estimation period. During this latter period fourth quarter exports have been higher than exports in the other quarters (which are not significantly different from one another). As already noted, this could reflect seasonal demand factors (e.g. an increase in demand for bacon and ham over the Christmas period).

9.5 Evaluation of the Stability of the Parameters in the Export and Import Equations

The stability of the parameter estimates for both equations was tested using the technique applied in other chapters. Five observations were dropped from the end of the sample period, the equations were re-estimated using this shorter sample period and the changes in coefficients were then tested for significance using an F test. The results are presented in Table 9.3. Because the computed F statistic is less than the critical value at the 5 percent level of significance in both instances, we accept that the structural coefficients in both equations are stable.

9.6 Conclusion

This chapter has discussed the specification, estimation and evaluation of the import and bacon export equations used to the New Zealand pig-meat model. Imports and bacon exports are both very small and highly volatile. The estimated equations described in this chapter give a satisfactory explanation of the movements in both of these variables.

Table 9.3

Testing the Structural Stability of the
Import and Export Equations

n	Imports		Exports	
	25	20	37	32
Constant	-12.58	-201.21	-1.01	0.6
L1FPB	2.92	5.16		
L1CFPB	15.79	12.58		
L1DMPT	-66.98	-106.2		
L1MPTS	0.591	0.45		
L1DRBC			-0.032	-0.047
L1DXB			5.86	8.04
L1XPTB			0.33	0.319
D2	-17.9	-50.4	4.35	3.95
D3	-67.1	-10.6	2.12	-0.28
D4	-289.1	-344.9	12.93	9.37
D317			51.03	51.9
D422			29.27	32.5
\hat{p}	- 0.61	-0.61	-0.387	-0.39
e	607,230.0	381,449.0	1,645.9	1,543.7
F	1.42		0.304	

CHAPTER TENSIMULATION ANALYSIS:
EVALUATION OF THE COMPLETE MODEL10-1 Introduction

This chapter discusses the use of simulation analysis to evaluate the simultaneous equation model outlined in Chapter Four. The 16 component behavioural relationships have been estimated and individually evaluated in Chapters Six to Ten. The model is completed and closed by combining these 16 estimated behavioural equations with four identities (for the two retail prices, the change in stocks and pork exports), non-negativity restrictions on imports and exports and the growth restriction on pork exports. When the model is in this complete form it can be solved for a consistent set of endogenous variables given values for the exogenous variables. This consistent set of model generated endogenous variables can then be used to evaluate the performance of the complete model.

The chapter is divided into five main sections. The first briefly discusses the nature of simulation analysis emphasising the use of simulation analysis in evaluating the static and dynamic features of the model both within and beyond the sample period. This section also briefly discusses the potential applications of the simulated model to forecasting and policy evaluation. Sections two to five are concerned with evaluating different aspects of the model's behaviour using simulation analysis. Section two discusses the stability of the model and the model's ability to reproduce the hypothesised inherent cycle in the pig-meat market. The third, fourth and fifth sections discuss the static properties of the model within the sample period, the model's potential for evolutionary forecasts and the model's ability to successfully forecast beyond the sample period respectively.

10.2 The Nature of Simulation Analysis

Simulation methods can be used to solve either the reduced or structural form of the model to find the current endogenous variables (Y_t) in terms of the lagged endogenous variables (Y_{t-1}), the exogenous variables (X_t) and the error terms (U_t). Labys notes that:

"Three different methods of generating values of Y_t are associated with model solution: partial, total and final. According to the partial method, data for the exogenous and policy variables X_t , the lagged endogenous variables Y_{t-1} , and the endogenous variables appearing on the right hand of the equations are fed into the computer, and one obtains a set of partial predictions for each of the endogenous variables, Y_t . The total method requires greater dependence on the model's ability to generate the Y_t , and only data for the exogenous variables X_t and the lagged endogenous variables Y_{t-1} are required. With the final method, values of the lagged endogenous variables Y_{t-1} as well as the current values of Y_t are generated by the model, and only values for the exogenous variables X_t are needed. This latter method ... implies evolutionary behaviour in which a model generates its own values for the endogenous variables Y_t over a large number of future periods."¹

The static characteristics of the model are best evaluated using the "total" method of model solution. Using the model to supply total solutions beyond the sample period is a reasonable test of the model's ability to provide internally consistent forecasts one period in advance. However, the "final" method of model solution is required to evaluate the dynamic characteristics of the model. It is only when the model is capable of reasonably accurate evolutionary behaviour beyond the sample period that it can be used confidently for medium to long term forecasts.

1. W. C. Labys, Dynamic Commodity Models: Specification, Estimation and Simulation, 1973, p.201.

The structural form of the model was used for the simulation analysis discussed in this chapter. Because principal components had been used in the first stage of the two stage estimating procedure an estimated reduced form of the model was unavailable. However the presence of nonlinearities in variables and of lagged endogenous variables in the model often prevents the direct simulation from the reduced form of the model and may make this solution less efficient.²

Labys notes that:

"Simulation based on the solution of the structural form of the model is presently the best approach to overcoming the difficulties caused by nonlinearities or lagged variables. Only now the method of solution requires the use of some iterative procedure particularly recommended is that of Gauss-Seidel."³

A Gauss-Seidel iterative procedure was applied in the program used to simulate with the model.⁴ The disturbances U_t may either be suppressed or generated to yield either deterministic or stochastic simulation. Only deterministic simulations using the model have been completed to date.

It is possible to validate the model based on either its analytical solution or the use of simulation analysis.⁵ Simulation analysis was preferred in this case because of its efficiency in generating time paths for the endogenous variables. The validity of the model will depend on its ability to predict the behaviour of the pig-meat market. As already noted this prediction can be applied to observations

2. Ibid, p.205-7

3. Ibid, p.207

4. The programme, Stochsim, was developed by R. McDougall, USDA. See R. McDougall, Program for Stochastic and Deterministic Simulation : Stochsim, Econometrics Section, Current Economic Analysis, April 1975.

5. For a brief discussion of the question of analytical versus simulation solutions see T. H. Naylor, "Policy Simulation Experiments with Macroeconometric Models: The State of the Art", American Journal of Agricultural Economics, Volume 52, No.2, May 1970, pp 263-271.

within or beyond the sample period utilising the static (total solution) or dynamic (final solution) properties of the model. However, there are major difficulties involved in validating models as no analytical basis exists for selecting the validation criteria which might be the most appropriate to use in particular circumstances.⁶

Johnson and Rausser list a large number of evaluation criteria for investigating the explanatory and predictive power of systems models.⁷ These include tests of the degree of conformity of simulated and actual time paths and comparisons of model forecasts and "naive" forecasts. The tests which have been traditionally applied to measure the forecast error between actual and simulated observations are single point criteria, such as the mean absolute percentage error, the mean squared error, and the Theil inequality coefficient. The Theil inequality coefficient can also provide information as to sources of error.⁸ These methods are probably the most practical for evaluating performance with historical sample or a small post-sample data set.⁹

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6. W. C. Labys, op cit, p.215. See also P. J. Dhrymes, et al, "Criteria for Evaluation of Econometric Models", Annals of Economic and Social Measurement, 1 July 1972, pp 291-324.
 7. S. R. Johnson and C. Ruasser, "Systems Analysis and Simulation: A Survey of Applications in Agricultural and Resource Economics", in A Survey of Agricultural Economics Literature, Volume 2, L. R. Martin (ed), University of Minnesota Press, 1977, pp 188-189.
 8. Theil's inequality coefficient can be decomposed into three inequality coefficients that explain the difference between the means of actual and simulated values (bias component); the difference between the variance of actual and simulated values (variance component); and the covariance between the two sets of values (covariance component).
 9. W. C. Labys, op cit, p.217

The mean absolute percentage error (MAPE) and Theil's inequality coefficient (Theil U) have been used in this study to evaluate the historical simulations as well as the post-sample simulations (which are limited to small post-sample data set). Although Theil's inequality coefficient is not decomposed to show the sources of error, a rough comparison of turning points is made.

Model simulations can be used instead of the analytical multiplier analysis to show the immediate, intermediate and long run impact of changes in exogenous variables on the endogenous variables in the model. Multiplier analysis makes use of the reduced form of the model which was not meaningfully estimated in this study (i.e. no economic meaning can be ascribed to the "reduced form" parameters associated with the principal components). Multiplier analysis is also of limited practical value when there are non-linearities or dynamic equations in the model.¹⁰

Given these problems and limitations associated with multiplier analysis, model simulations could be used to determine the dynamic impact of a change in any one of the exogenous variables on any (or all) of the endogenous variables for any particular time period. The exogenous variables could be set at alternative levels and the impact of these changes on the endogenous variables calculated by simulating the model over the period in question. The simulated alternative time paths for the endogenous variables could then be compared to derive the net impact of the changes in exogenous variables. The value of deriving multipliers from the model is very limited in practice. The time involved in generating these multipliers for any more than an extremely limited subset of exogenous variables is also

10. W. C. Labys, op cit, p.188

substantial. Therefore, individual multipliers have not been calculated in this study. However, some highly conditional partial forecasts have been made illustrating the impact of one exogenous variable (feed costs) on a limited (partial) set of endogenous variables. This application is discussed in Chapter Eleven.

Model simulations can also be used to determine the underlying stability conditions of the model (rather than relying on analytical evaluations of model stability¹¹). The stability of the New Zealand Pig-meat Model is discussed in the next section of this chapter. The model has been simulated over a number of quarters with the values of all of the exogenous variables being constant over the entire period of the simulation. This type of simulation can be used to determine the stability characteristics of the model (e.g. does the model exhibit cyclic behaviour and do the endogenous variables gravitate towards some equilibrium level?)

Although this chapter is primarily concerned with the application of simulation techniques to enable the validation of the model, the models forecasting ability and applicability as a policy evaluation tool are also important. Simulation techniques have obvious application in both areas. As long as exogenous variables are available, the simulation model will generate a forecast for a consistent set of endogenous variables. If forecasts beyond one period (quarter) are required, the simulation model will use its own forecasts as lagged endogenous variables. The accuracy of the resulting forecasts will be as good as the ability of the model to forecast endogenous values for a given set of exogenous values and the ability of model users to accurately forecast these exogenous values. Therefore these forecasts are conditional on the values of the exogenous variables. The use of the simulation model for policy evaluation is an application of

11. For a brief discussion of the analytical approach to evaluating a model's stability see W. C. Labys, op cit, pp 169-181.

highly conditional forecasting. Instead of setting all the exogenous variables at their most likely levels, policy instruments are set at alternative levels (to represent alternative policies) and the calculated endogenous variables represent alternative policy outcomes. Naylor has discussed this "policy simulation" approach and compared it with the Theil "welfare criterion" approach and the Tinbergen "target value" approach as a means of performing policy analysis.¹² The "policy simulation" approach does not require policy makers to make their welfare preferences or targets explicit. The policy maker chooses between alternative policies on the basis of alternative model simulated outcomes. The applicability of the model to policy evaluation in the pig industry is discussed in Chapter Eleven.

10.3 Model Stability

If the model is to be considered an adequate representation of the pig-meat market; the underlying characteristics of the model must be compatible with those of the market. In Chapter Three, two theoretical models of the pig-meat market were discussed which demonstrated that:

"the existence of a production lag in combination with price expectations based on current prices will produce production and price cycles in an otherwise perfectly competitive market modifications to the underlying market dynamics should not obscure the importance of economic friction and imperfect knowledge in generating market instability".¹³

That chapter postulated that instability in the pig-meat market was caused by exogenous shocks in combination with an "inherently" unstable market structure (a result of economic friction and imperfect knowledge). However, no hypothesis was formed concerning the exact nature of this inherent instability. The

12. T. H. Naylor, op cit, pp 263-265

13. Chapter Three, section 3.3.1, p.43

simple cobweb model will produce exploding, imploding or constant oscillation cycles for alternative assumptions about the slopes of the supply and demand curves. Although the model developed in this thesis is considerably more complex than the simple cobweb representation, it is possible for the inherent instability in the New Zealand pig-meat market to take almost any of these forms. The actual "inherent" portion of the recorded instability in the market is never separately identified because the actual market is continually subjected to exogenous shocks. However, it is possible to separately identify this inherent instability using simulation analysis by defining all the exogenous variables as constants and solving the model using the "final method" described by Labys. If the model is an accurate representation of the hypothesised market structure then we would expect the time paths of the endogenous variables generated in this way to show some cyclical variation which may or may not diminish (e.g. as the variable approaches some equilibrium position). The ability of the model to adequately represent this "inherent" behaviour is an important measure of its validity.

In order to identify the inherent instability generated by the model, all of the exogenous variables were set equal to their 1971 (first quarter) value and the (unrestricted¹⁴) model simulated over 40 quarters using model generated endogenous variables as lagged values (i.e. using the "final method" of simulation). The endogenous variables exhibited some cyclic behaviour before moving towards a stable (equilibrium) growth path. A reasonably typical path generated by the model is illustrated in Figure 10-1 where the simulated "inherent" cycle in North Island baconer production is shown. This graph indicates that the inherent instability in the market is definitely convergent towards some equilibrium value (in this case a small negative "equilibrium" growth rate). The mean cycle length appears

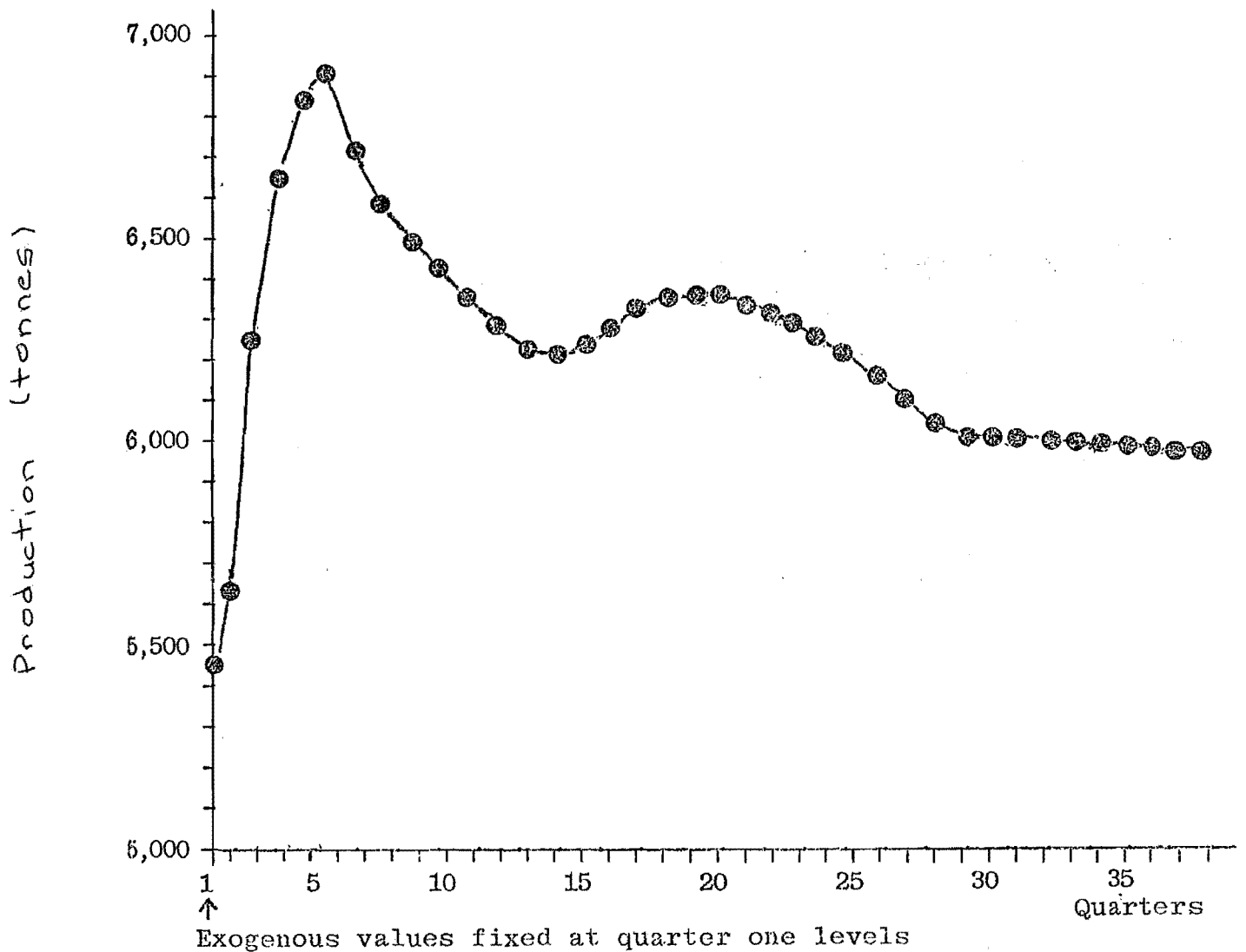
14. The non-negativity and growth rate restrictions on exports and imports were lifted.

to be 14 quarters (peak to peak) which is consistent with our a priori range for the production cycle and is only slightly shorter than the 16 quarter cycle often accepted as the "inherent" hog cycle in the United States.¹⁵

Although the stability characteristics of the model are compatible with the widely accepted view of the dynamics of the actual market, the model simulation described

Figure 10-1

Inherent Cycle in North Island Baconer Production



15. See, for example, A. A. Harlow, "The Hog Cycle and the Cobweb Theorem", Journal of Farm Economics, Volume 42, November 1960, pp 842-853.

above did indicate that the behaviour of the model was not completely acceptable. In particular the "equilibrium" growth paths generated for the North Island variables were not consistent with a priori expectations. Table 10-1 shows the direction of these growth paths for each endogenous variable:

Table 10-1

Direction of Inherent "Equilibrium" Growth Paths
for Each Endogenous Variable*

PCS	+	DFPBS	+	DFPPS	+	PCCB	-
XPTB	-	PBS	+	PCN	+	DMP	+
MPTS	+	DFPPN	+	DRPK	+	DMB	+
DFPBN	+	PPN	-	PCCP	-	CHST	+
PBN	-	PPS	+	DRBC	+	XPTP	+

* These variable names are defined in Table 10-3.

The directions of virtually all of those growth paths are compatible. For example, increasing retail prices are associated with falling retail consumption and increasing farm prices in the South Island are associated with increasing farm production in this region. However, increasing farm prices in the North Island are associated with falling production. Although these equilibrium growth rates are extremely small (e.g. less than 0.2 percent for PBN) this inverse trend relationship in the North Island is a cause for concern. However, given the evaluation of the North Island baconer production equation, it is not an entirely unexpected long run phenomenon (because of the very large negative coefficient associated with the lagged farm price of porkers). Steadily rising baconer prices will tend to force up porker prices. Although a priori we would expect the effect of the lagged baconer price to have the greatest effect on baconer production, the excessive coefficient attached to the lagged porker price actually results in an inverse net long run relationship.

Therefore, although the model's stability characteristics are consistent with the stability characteristics of the market, the North Island baconer production equation requires re-specification.

10.4 The Static Properties of the Model : The Ability to Forecast One Period in Advance Within the Sample Period

This section discusses the results of a "total" deterministic simulation with the structural form of the model over a portion of the sample period (i.e. from 1971 (second quarter) to 1979 (second quarter)). The summary results are presented in Table 10-2. Figures 10-2 to 10-9 illustrate the simulation results for eight of the most important variables in the model. Because of the change in grading classification in 1973, the 'average production' variables in the price equations will be a mixture of pre and post classification change from the fourth quarter of 1973 to the third quarter of 1974 inclusive. Therefore these observations have had to be ignored in calculating the summary statistics presented in Table 10-2. There are only two observations (in the PCS equation) and six observations (in the MPTS equation) that were excluded during the estimation of other equations in the model. Because the influence of these variables over the periods in question was extremely small, and in an effort to maintain a large sample size, these two variables were set equal to their actual values during these periods.

A comparison of the R^2 's generated from the simulation is interesting. We would expect some slight changes in the values of this statistic because of the slightly different "estimating" period and the influence of setting actual and predicted values equal for a restricted period in the PCS and MPTS equations.

Table 10-2

Results of Total Simulation of New Zealand Pig-Meat Model from 1971 (second quarter) to 1979 (second quarter)

Endogenous Variable1	R Square ²		Theil U	% Turning Points Currently Predicted ³	MAPE	Standard Error/ Mean of Variable
	2SPC Estimate	Simulation Estimate				
PCS	0.82	0.95	0.26	86	5.39	0.187
XPTB	0.89	0.87	0.44	77	34.75	0.89
MPTS	0.79	0.79	0.74	80	144.55	0.95
DFPBN	0.94	0.87	1.51	80	4.70	0.14
PBN	0.83	0.81	0.58	87	5.11	0.14
DFPBS	0.95	0.89	1.52	83	4.49	0.17
PBS	0.97	0.98	0.43	93	3.68	0.29
DFPPN	0.95	0.89	1.29	77	3.43	0.13
PPN	0.95	0.89	0.74	87	7.25	0.24
PPS	0.98	0.98	0.50	84	5.66	0.45
DFPPS	0.93	0.88	1.37	83	6.22	0.20
PCN	0.81	0.79	0.78	83	12.74	0.27
DRPK	Identity	0.94	0.84	83	1.66	0.08
PCCP	0.94	0.94	0.61	87	6.49	0.28
DRBC	Identity	0.92	1.00	83	1.63	0.07
PCCB	0.89	0.88	0.51	93	4.12	0.13
DMP	0.83	0.83	0.66	76	1.76	0.05
DMB	0.93	0.94	0.88	76	1.39	0.06
CHST	Identity	0.82	0.44	97	48.39	1.58
XPTP	Identity	0.07	1.86	50	111.45	1.11

1. These variable names are defined in Table 10-3.
2. These are not strictly comparable because of the different periods used in estimation and simulation.
3. The number of times a directional change was correctly predicted divided by the total number of observations multiplied by 100.

Given this source of divergence, the R squared's presented in Table 10-2 are very similar. This implies that the purged

Table 10-3

Listing of Endogenous Variables in the Model

<u>Identification</u>	<u>Definition*</u>
PCS	Quantity of chopper meat produced in South Island
XPTB	Quantity of cured pig-meat exported
MPTS	Quantity of pig-meat imported
DFPBN	Deflated farm price of bacon weight pigs in North Island
PBN	Quantity of bacon weight meat produced in North Island
DFPBS	Deflated farm price of bacon weight pigs in South Island
PBS	Quantity of bacon weight meat produced in South Island
DFPPN	Deflated farm price of pork weight pigs in North Island
PPN	Quantity of pork weight meat produced in North Island
PPS	Quantity of pork weight meat produced in South Island
DFPPS	Deflated farm price of pork weight pigs in South Island
PCN	Quantity of chopper meat produced in North Island
DRPK	Deflated retail price pork
PCCP	Per Capita consumption of pork
DRBC	Deflated retail price of cured pig-meat
PCCB	Per Capita consumption of bacon
DMP	Deflated farm to retail price margin for pork
DMB	Deflated farm to retail price margin for cured pig-meat
CHST	Change in stocks of pig-meat
XPTP	Quantity of pork exported

* All quantities are expressed in tonnes and all prices in cents per kilogram. A detailed description of both endogenous and exogenous variables appears in Appendix A.

Figure 10-2

Comparison of Actual and Simulated Values for
North Island Baconer Production for the Period 1971
(second quarter) to 1979 (second quarter)

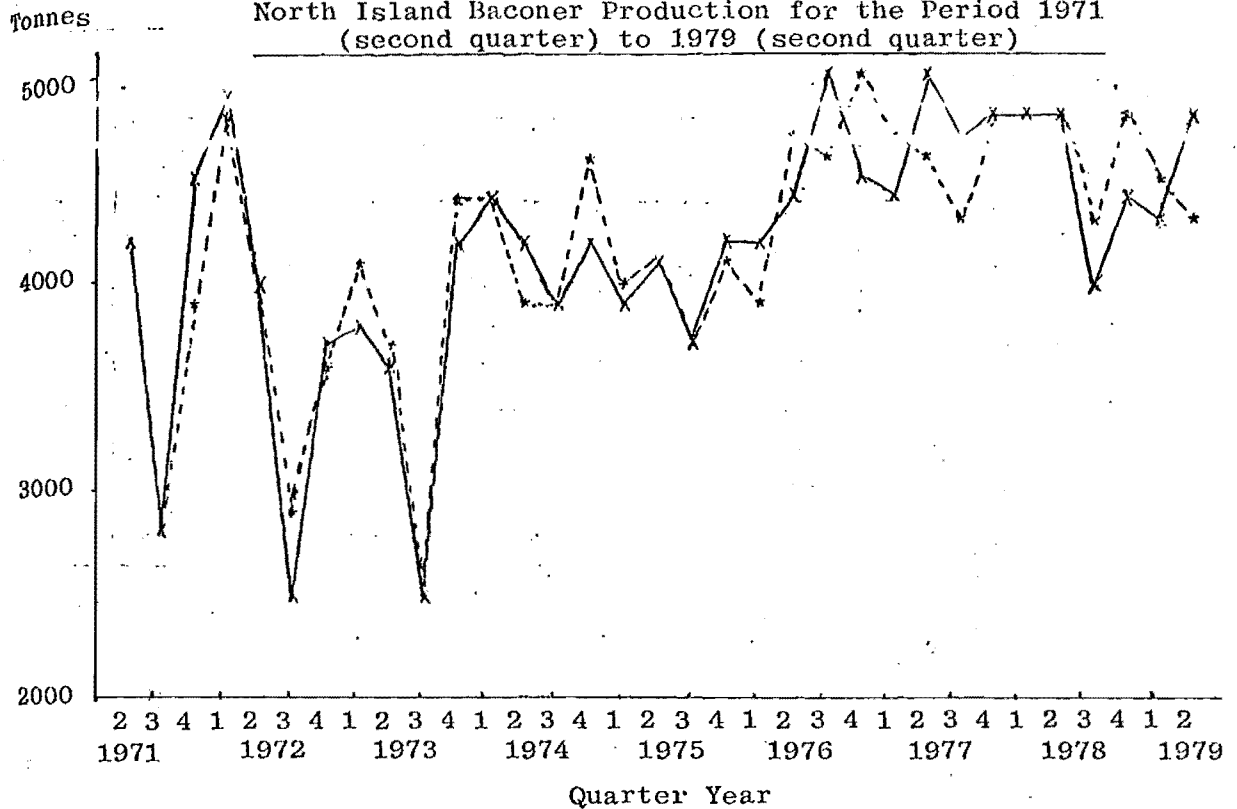


Figure 10-3

Comparison of Actual and Simulated Values for
South Island Baconer Production for the Period 1971
(second quarter) to 1979 (second quarter)

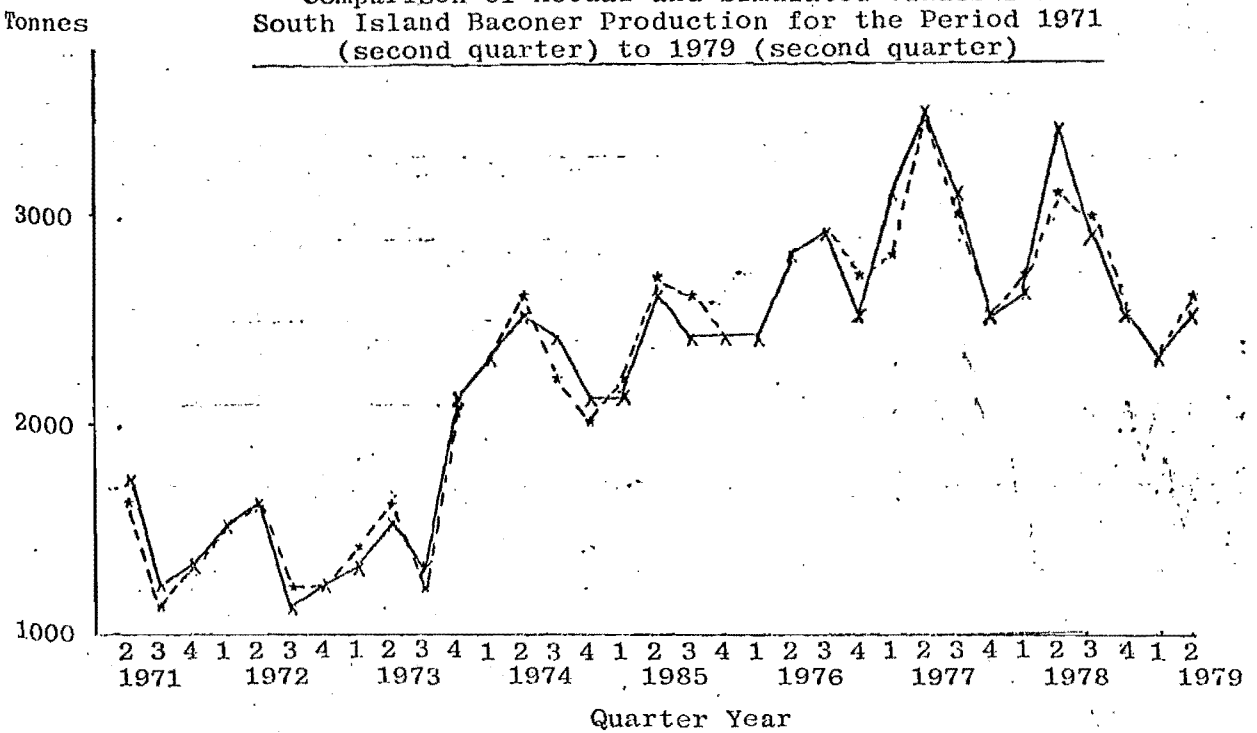


Figure 10-4

Comparison of Actual and Simulated Values for
North Island Porker Production for the Period 1971
(second quarter) to 1979 (second quarter)

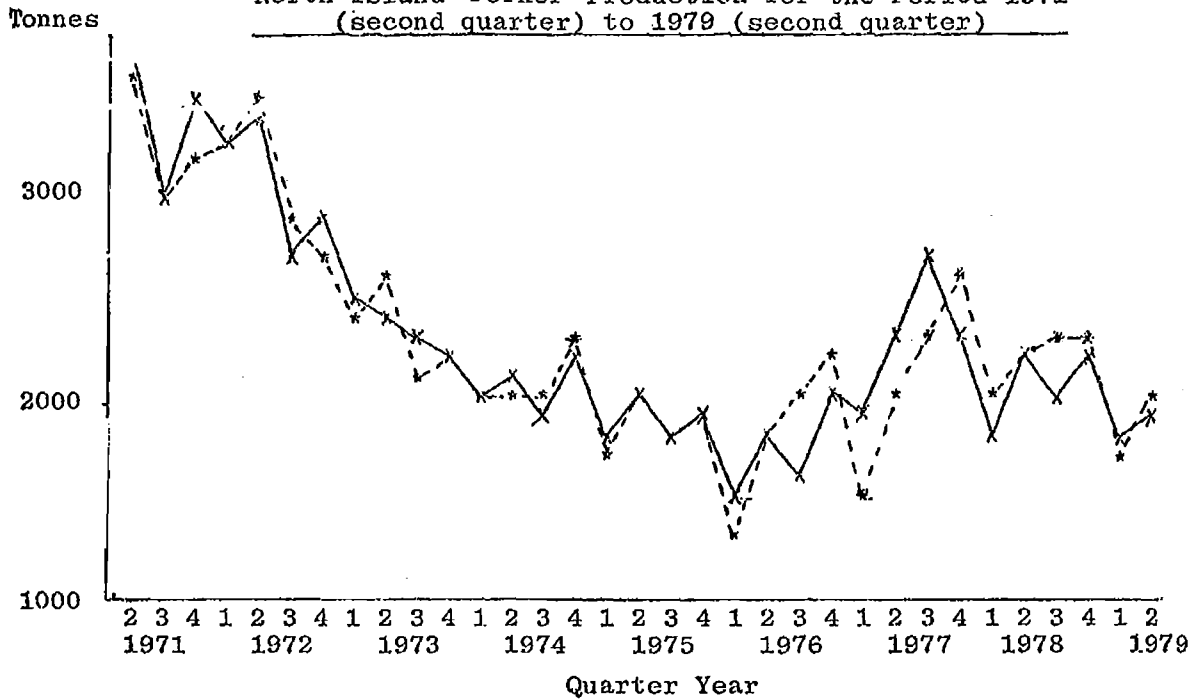


Figure 10-5

Comparison of Actual and Simulated Values for
South Island Porker Production for the Period 1971
(second quarter) to 1979 (second quarter)

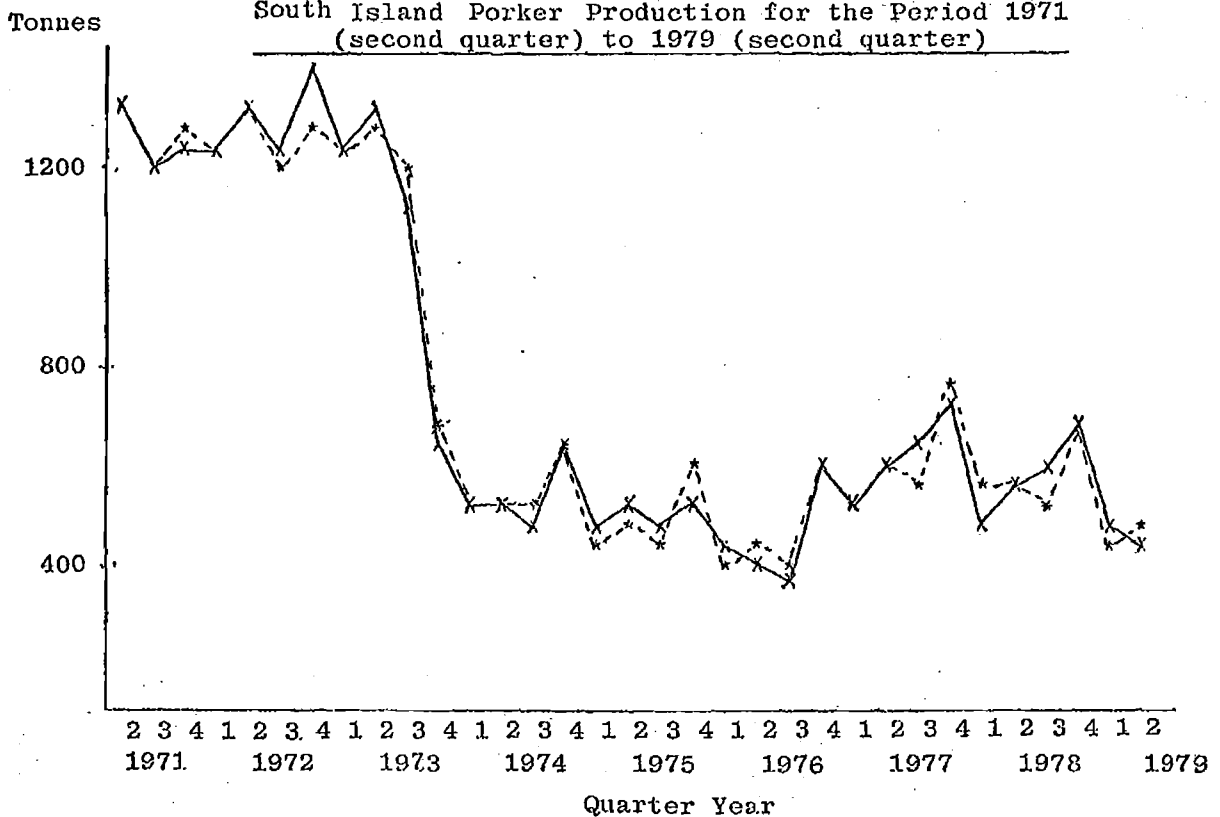


Figure 10-6

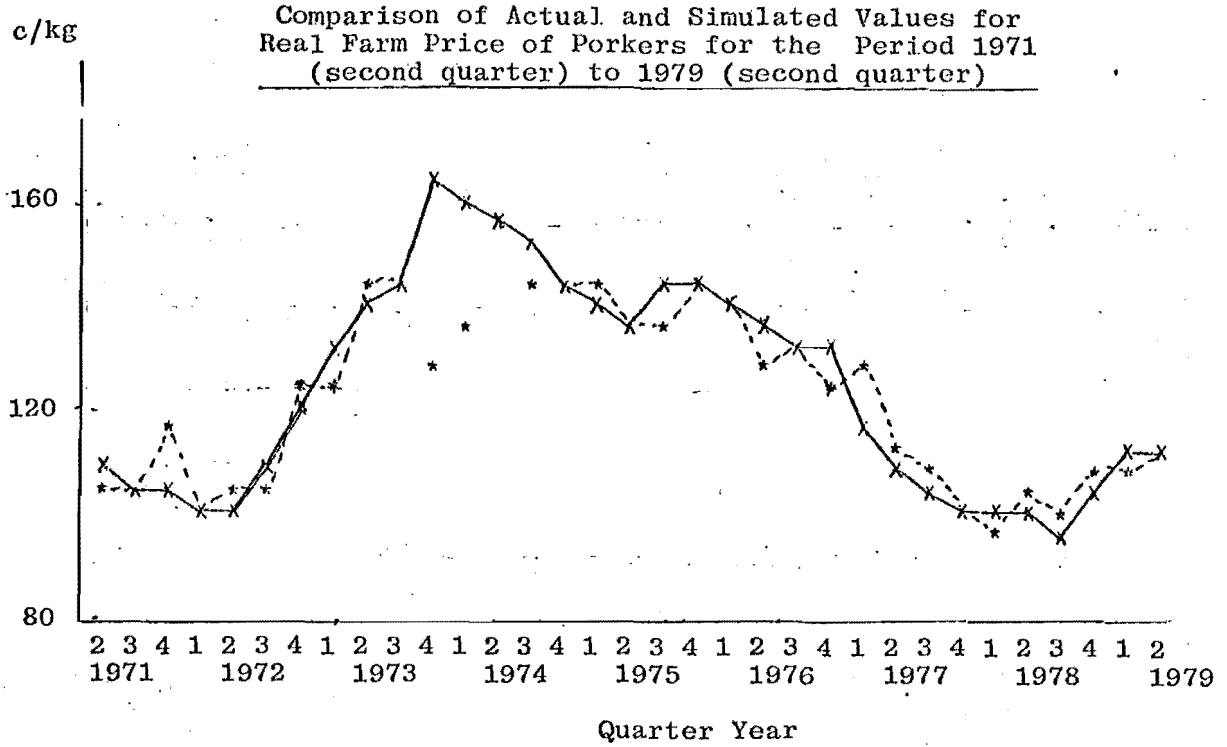


Figure 10-7

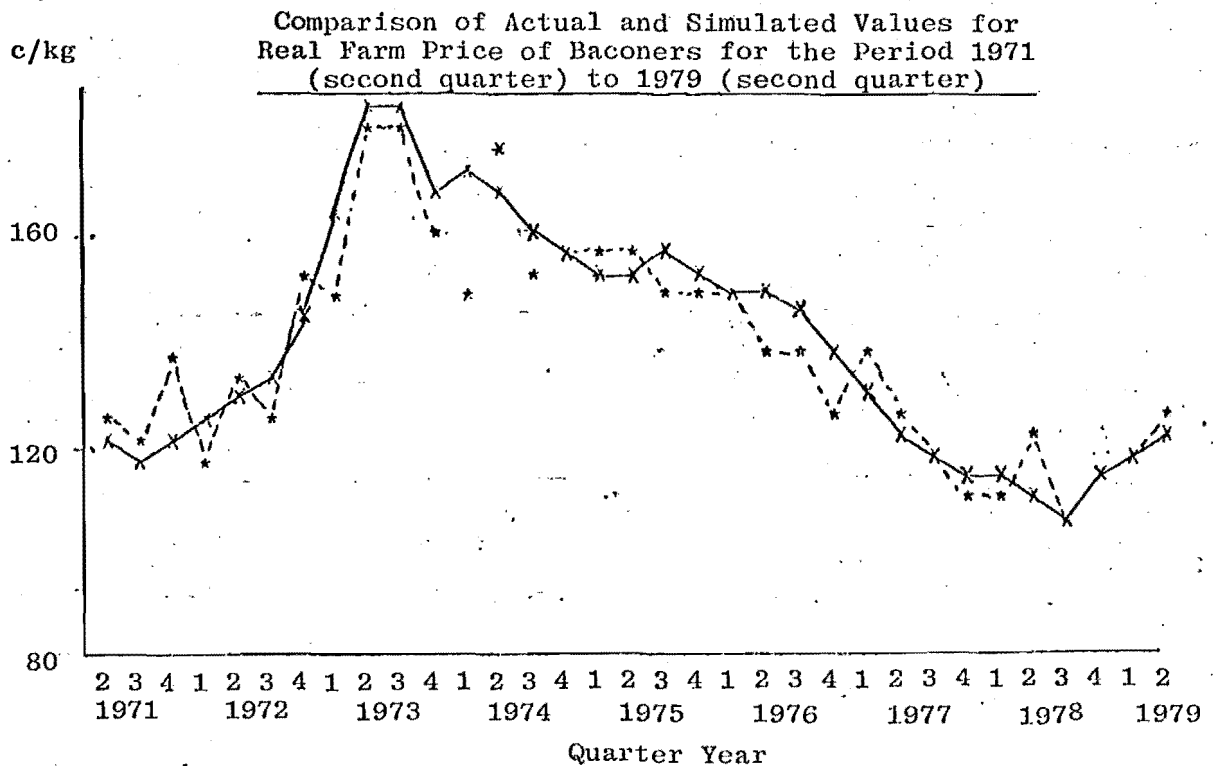


Figure 10-8

Comparison of Actual and Simulated Values for
Per Capita Consumption of Fresh Pork for the Period
1971 (second quarter) to 1979 (second quarter)

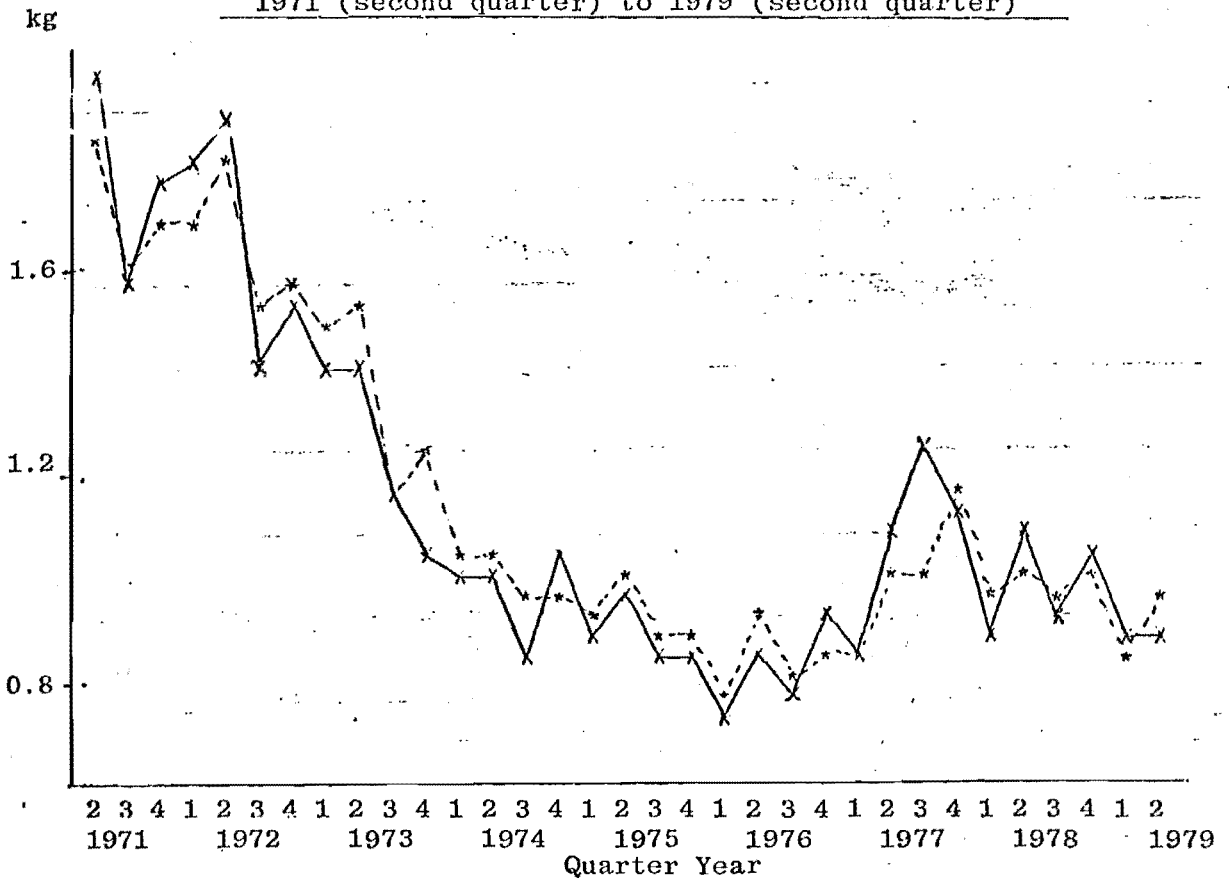
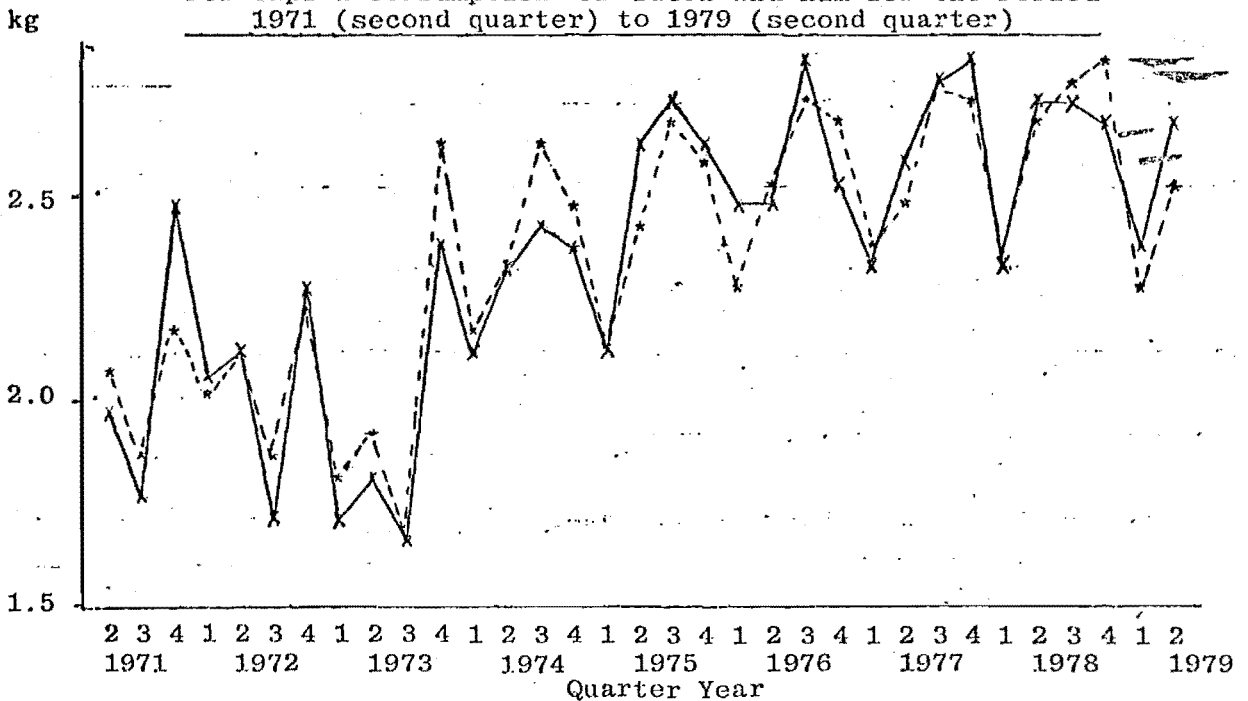


Figure 10-9

Comparison of Actual and Simulated Values for
Per Capita Consumption of Bacon and Ham for the Period
1971 (second quarter) to 1979 (second quarter)



endogenous variables used in the second stage of 2SPC have a similar influence on the (other) endogenous variables as the simulation model generated endogenous variables used as explanatory variables in the simulation model. Another interesting feature is the simulated R^2 's reported for the identity equations in the model. The two retail price identities (i.e. DRPK and DRBC) and the 'change in stocks' identity (i.e. CHST) have a very satisfactory explanatory ability. Given that the errors in the cured products production and consumption equations will net out in the 'change in stocks' identity, and that the errors in all of the farm price and margin equations will nett out in the two retail price identities, these are especially pleasing results. On the other hand, the R^2 calculated for the export pork identity (XPTP), is extremely low. This is not altogether surprising. The average value of fresh pork exports is only 3.6 percent of average fresh pork production so that extremely small errors in either production or consumption will result in extremely large errors in the estimate of fresh pork exports. This is demonstrated by the very high MAPE associated with XPTP while the MAPES associated with the fresh pork production and consumption equations are low.

The inequality coefficient (Theil U) for each equation is also reported in Table 10-2. The values that this coefficient assumes lie between 0 and ∞ ; the smaller the coefficient, the better is the forecasting performance of the equation. If the change in the predicted value is equal to the change in the actual value then this coefficient equals zero. If the coefficient is equal to one then the equation forecasts are no better than 'naive' zero-change prediction (i.e. $\hat{Y}_t = Y_{t-1}$). If the coefficient exceeds unity then the predictive power of the equation is worse than a zero change prediction.

An examination of Table 10-1 indicates that only five of the 20 equations have Theil U coefficients greater than unity, with one coefficient equal to unity. Apart from the XPTP

equation (which is unlikely to forecast well because of the reasons discussed above), this problem is confined to the farm price equations. Given the importance of the DFPBN equation in determining farm prices it is probable that this equation is the source of most of the forecast errors in the model. This throws further suspicion on the DFPBN equation and especially on the importance of stocks in determining the farm price for baconer pigs and the accuracy of the 'change in stocks' variable. Although the farm price equations predictions are inferior to naive zero-change predictions, the MAPE's associated with these predictions are small (i.e. average under 5 percent) and the proportion of turning points correctly predicted is large (i.e. exceeds 80 percent). In addition, the problems associated with the relatively poor predictive power of these equations has not rendered the other equations in the model inferior to naive forecasts.¹⁶

Of the equations in the model, only four have very large MAPES (i.e. XPTB, MPB, CHST and XPTP). All of these equations represent small, and highly volatile, quantities of pig-meat (on "average" the standard error of these variables exceeds the corresponding mean value). Therefore, although the model forecasts of these variables are accurate when measured by a number of other criteria, it is not surprising that the MAPES associated with these forecasts are large. When these four equations are excluded, the average MAPE for the other 16 equations falls to 4.7 percent.

Apart from the XPTP equation, all of the equations in the model forecast the direction of change in the endogenous variables reasonably well. Table 10-2 indicates that, on average, these equations correctly predicted 84 percent of the directional changes in the endogenous variables.

16. Although when the predicted values for farm prices are set equal to their actual values (so that this source of error is removed), the "average" Theil U for the other 16 equations falls from 0.7 to 0.6.

The figures presented in Table 10-2 indicate that, although the forecasting ability of some equations is not particularly good, the model as a whole is able to provide reasonably accurate forecasts for most of the endogenous variables. In particular, although the model forecasts for farm prices and fresh pork exports are not as good as naive forecasts of the same variables (and model forecasts of retail cured product prices are no better), the model's ability to forecast the other endogenous variables one period in advance within the sample period is superior to naive "model" forecasts.

10.5 Medium to Long Term Forecasts : An Evaluation of the Model's Evolutionary Behaviour

This section discusses the results of a "final" deterministic simulation with the structural form of the model over a restricted within-sample period (i.e. from 1974 (fourth quarter) to 1979 (second quarter)). These results are compared with the model's ability to generate "static" forecasts (i.e. forecasts one period in advance). Unfortunately, because of the influence of the grading change on the "average production" variables, the period prior to 1974 could not be included in the simulation.

The ability of the model to generate acceptable "dynamic" forecasts is an important test of the usefulness of the model in generating medium to long term forecasts (i.e. forecasts for periods longer than one period in advance). If the model can successfully generate accurate forecasts of the endogenous variables using previous forecasts as lagged variables, then the model is useful as a medium to long range forecasting tool.

The results of both the total (static) and final (dynamic) simulations for the period are presented in Table 10-4. The first point to note is that both static and dynamic results

Table 10-4

Comparison of Total and Final Simulations of
the New Zealand Pig-Meat Model from 1974
(fourth quarter) to 1979 (second quarter)

Endogenous Variable	Total (Static) Simulation		Final (Dynamic) Simulation	
	Theil U	MAPE	Theil U	MAPE
PCS	0.24	5.2	0.28	7.2
XPTB	0.74	40.6	0.76	45.4
MPTS	0.79	218.2	0.90	265.9
DFPBN	2.12	3.9	2.10	11.4
PBN	1.07	5.5	1.02	9.7
DFPBS	1.36	4.4	1.16	12.4
PBS	0.47	3.4	0.43	5.1
DFPPN	1.34	3.2	1.05	7.1
PPN	0.85	8.6	0.74	13.1
PPS	0.50	6.9	0.50	8.4
DFPPS	1.21	5.8	1.00	11.2
PCN	1.17	12.5	0.80	19.2
DRPK	0.78	1.2	1.08	4.7
BCCP	0.69	6.5	0.63	6.2
DRBC	1.13	1.1	1.37	4.4
PCCB	0.53	3.3	0.48	4.2
DMP	0.71	1.5	0.81	3.8
DMB	0.90	1.1	0.94	2.8
CHST	0.52	46.9	0.50	131.5
XPTP	1.51	120.2	1.81	183.1
Average	0.93	25.0	0.91	38.0
Average ¹		4.6		8.1

1. Excludes the worst four equations; XPTB, MPTS, CHST, XPTP.

for this restricted period are generally inferior to the static results for the longer period presented above (although the MAPE for the total simulation is identical to that for the total simulation presented above). This is not an unexpected result. The parameter estimates have been calculated over a period more than twice as long as the 1974-79 period used for these simulations and, therefore, these parameters are not ideally suited to a more restricted period. Therefore, the comparison between total and final simulations can only be made when an identical simulation period is considered.

The second point to note about the results presented in Table 10-4 is that using the Theil U criteria, the dynamic forecasts for the period are as good as the static forecasts for the same period. The poor forecasting ability of the farm price equations is still apparent but, for this restricted period, has had a more dramatic effect on the forecasting ability of the retail price equations and the North Island baconer supply equation. The Theil U coefficients for the dynamic forecasts indicate that, over this restricted period, 12 equations performed better than naive forecasts, four equations performed as well as naive forecasts and four equations performed worse than naive forecasts.

Despite the fact that the average Theil U coefficient for static and dynamic forecasts are identical, the MAPEs of the dynamic forecasts are considerably larger than the MAPEs of the static forecasts. Therefore, although dynamic simulations are likely to improve the medium to long term forecasting ability of policy makers, these longer term forecasts will not be as precise as the short term static forecasts. Although any lack of accuracy is unfortunate, the relative increase in the MAPE associated with dynamic forecasts is unlikely to prejudice the use of these forecasts in practice. Medium to long term forecasts are primarily indicative (i.e. policy makers are interested in general trend movements over the long term) and are usually highly conditional in practice.

The actual forecast error is sensitive to the forecast values for the exogenous variables used as well as the forecasting ability of the model. Therefore policy makers tend to set values for exogenous variables that reflect what they perceive as alternative future scenarios rather than attempting to forecast the most probable values for exogenous variables. These alternative sets of time paths for the exogenous variables yield highly conditional forecasts for the endogenous variables (i.e. more of a "what would happen if" type of analysis than a "what is most likely to happen" analysis). Given the limited ability of policy makers to forecast future values for the exogenous variables this is an intelligent use of the longer term forecasting ability of the model.

10.6 The Ability of the Model to Forecast Beyond the Sample (Estimation) Period

This section evaluates the model's ability to forecast beyond the initial period used to estimate the model. Unfortunately only three post-sample period observations are available (i.e. 1979 (third quarter) to 1980 (first quarter)). This is insufficient to test the dynamic forecasting ability of the model beyond the sample period and renders an accurate evaluation of the post sample static forecasting ability of the model difficult.

The results of this simulation are reported in Table 10-5. A comparison of the MAPE and 'proportion of total turning points accurately predicted' within and beyond the sample period indicates that the "average" performance of the model in the post-sample period is worse than its performance within the sample period. However, it is very difficult to form conclusive opinions on the forecasting ability of the model using such a short post-sample period. This deterioration in the post-sample forecasting ability of the model may be due to either abnormal conditions in the

Table 10-5

EVALUATION OF MODEL FORECASTS OUTSIDE SAMPLE PERIOD

Exogenous Variable	Actual and Predicted Data			Post Sample MAPE	Sample MAPE		% Total Turning Points Predicted	
	1979 (3)	1979 (4)	1980 (1)		Whole Period	Worst 3 Qtrs	Post Sample	Sample
PCS - Actual	141.00	116.00	161.00					
Forecast	139.00	118.00	138.00	6.16	5.3	11.3	100	86
XPTB - Actual	11.1	8.4	5.8					
Forecast	2.7	10.8	7.3	43.90	37.7	103.3	66	77
MPTS - Actual	626.2	1,047.7	492.2					
Forecast	418.4	343.7	505.2	34.20	144.5	511.6	66	80
DFPBN - Actual	121.36	124.71	123.78					
Forecast	112.75	123.47	130.54	4.46	4.7	6.0	66	80
PBN - Actual	4,281.0	4,491.0	4,846.0					
Forecast	3,885.0	4,031.0	3,648.0	14.07	5.1	8.3	33	87
DFPBS - Actual	122.98	128.60	120.03					
Forecast	116.98	132.20	134.0	6.36	4.5	10.0	33	83
PBS - Actual	2,680.0	2,279.0	2,535.0					
Forecast	2,422.0	2,077.0	2,130.0	11.43	3.7	6.3	66	93
DFPPN - Actual	115.69	120.81	110.58					
Forecast	105.89	120.58	125.19	7.23	3.4	5.1	33	77
PPN - Actual	1,608.0	1,688.0	1,434.0					
Forecast	2,035.0	1,916.0	1,135.0	20.23	7.2	16.6	66	87
PPS - Actual	403.0	522.0	400.0					
Forecast	427.0	612.0	457.0	12.59	5.7	9.3	33	84
DFPPS - Actual	127.0	137.9	127.5					
Forecast	127.8	139.0	129.5	0.96	6.2	11.3	100	93
PCN - Actual	316.0	237.0	295.0					
Forecast	325.6	314.9	280.8	13.33	12.7	22.7	100	83
DRPK - Actual	305.9	329.4	331.8					
Forecast	290.5	312.6	330.2	3.50	1.7	2.7	66	83
PCCP - Actual	783.9	797.9	717.8					
Forecast	837.7	772.9	629.6	7.36	6.5	10.3	66	87
DRBC - Actual	540.8	573.8	588.8					
Forecast	524.7	547.4	588.5	2.52	1.6	2.56	66	83
PCCB - Actual	2,539.3	2,557.7	2,308.6					
Forecast	2,760.1	2,558.4	2,177.4	4.74	4.1	7.0	66	93
DMP - Actual	187.9	204.5	217.6					
Forecast	189.9	187.4	203.8	6.13	1.8	2.2	33	76
DMB - Actual	418.8	447.8	466.3					
Forecast	410.5	420.8	456.7	3.37	1.4	3.3	66	76
CHST - Actual	-311.0	-250.0	600.0					
Forecast	-1,848.0	-1,622.0	-578.0	412.6	48.4	105.0	66	97
XPTP - Actual	33.0	48.8	33.4					
Forecast	292.2	232.9	29.6	390.6	111.4	221.0	33	50
Average				50.3	20.7	53.8	61.2	82.2

1. % Total Turning Points Predicted is calculated as the total number of directional changes forecast by the model.
2. Sample MAPE refers to that period from the 1971 (second quarter) to 1979 (second quarter) excluding the fourth quarter of 1973 to the second quarter of 1974 (i.e., the period in which the value of the averaged production series is perturbed by the change in slaughter classification in the third quarter 1973).

forecast period or to structural changes in the market between sample and post sample periods. It is only the presence of structural changes that alter the underlying behavioural relationships that affect the model's validity for forecasting outside the estimation period.

The sensitivity of the parameter estimates in each equation to changes in the sample period has been evaluated in Chapters Six to Ten. All of the parameters in the model were found to be stable at the 1 percent level. However, some equations were close to (or exceeded) the critical F value at the 5 percent level so it is possible that some important structural changes may have started to occur since the second quarter of 1978. However, these changes are not obvious and it would be wrong to dismiss the influence of "abnormal conditions" on such a limited forecast period.

A very crude measure of the significance of "abnormal conditions" within the estimation period is the largest MAPE for any previous three consecutive quarters. A comparison of the post-sample forecasts with these "worst" within sample forecasts indicates that, on "average", the deterioration in post-sample forecasts is not outside the range of MAPE's for a within sample period of comparative length.

However, what these average figures hide is the tremendous variation in the post-sample performance of individual equations. While the post-sample performance of some equations is superior to their within sample performance (based on either MAPE or "turning point" criteria), some equations perform particularly poorly in the post sample period. The two baconer and porker production equations, the North Island farm price for porkers equation and the porker margin equations all perform badly when both MAPE and crude turning point criteria are used. However, given the very small post-sample size, the results are indicative rather than conclusive. The evaluation of the production equations

in Chapter Nine highlighted a number of inconsistencies between the parameters in these equations. Given these inconsistencies we might expect the performance of these equations to be variable (e.g. these equations could not be expected to perform well when explanatory variables - especially the ratio of baconer to porker prices - vary too greatly from their mean values). The pork margin equation also performs comparatively badly in the post-sample (although the MAPE is still small compared to that for other equations). This is surprising given the stability of this equation when subject to a reduction in sample size (see Table 6-1 and accompanying discussion). "Abnormal conditions" could well have affected the performance of this equation. Finally, it is interesting to note the relative stability of the two consumption and retail price equations; all perform well in the post-sample period despite the problems associated with other variables in the model.

Unfortunately, because of the very small post-sample size, no firm conclusions can be drawn from this analysis. However, the results indicate that, although the performance of the model as a whole deteriorates from the MAPE for the entire sample period, the post-sample results are not outside the range of MAPEs for a similar length within-sample period. These results also indicate that the performance of the retail portion of the model is relatively insensitive to forecast errors in farm production.

10.7 Conclusions

This chapter has been primarily concerned with the application of simulation analysis to validate the complete model. Although this is not the only technique available to evaluate the validity of a commodity model, it is the most useful in this instance.

The stability characteristics of the model as well as the model's ability to forecast both statically and dynamically

within the sample period and statically outside the sample period have been evaluated. In most respects the model has performed satisfactorily. It is able to reproduce an "inherent" pig cycle. This cycle is convergent with a mean length of about 3.5 years. Apart from difficulties in forecasting farm prices, model forecasts are likely to be accurate enough to be useful to policy makers. However the accuracy of these forecasts is likely to decline as the forecast period is increased and as this period is extended further beyond the original estimation period. As work is currently underway which should enable the re-estimation of the model this problem is not of major importance.

The model's potential to provide long term (evolutionary) forecasts is also acceptable, although these forecasts are likely to have larger errors associated with them. The model is therefore more useful providing highly conditional forecasts (i.e. evaluating the impact alternative scenarios) than long term predictions of market variables (i.e. "most likely" forecasts). This is coincident with the interests of policy makers whose ability to provide accurate forecasts of exogenous variables also limits the usefulness of the model in providing long term predictions.

The least satisfactory aspects of the model's forecasting behaviour are the model generated farm price forecasts. These forecasts are not good enough for use as an instrument of stabilisation policy (i.e. to improve producers' production decisions). Considerably more work needs to be done to improve the long term forecasting of farm prices. Although this inability to improve on a naive forecast of farm prices limits the use of the model as a policy instrument, it does not render the model useless as a policy tool. Model forecasts of other endogenous variables are acceptable despite the difficulties in forecasting farm prices. The use of the model to evaluate alternative policies is also likely to require that farm prices be set exogenously (i.e. farm prices are the Pork Marketing Board's main policy instrument).

associated

Chapter Eleven discusses the problems ^{associated} with the present model, the developments needed to improve its forecasting ability, and the usefulness of the model in its present form in detail. The forecasting ability of the model with exogenously determined farm prices is also discussed.

CHAPTER ELEVENCONCLUSION : APPLICATIONS AND DEVELOPMENTS11.1 Introduction

Chapter One discussed the objectives of this study:

"The objective of this study is to provide policy makers in the pig industry with a quantitative description of their industry that is usable, credible and sufficiently accurate to improve their ability to anticipate and respond to problems facing the industry."¹

This chapter discusses the extent to which this objective has been achieved and the developments needed to improve the model's ability to represent changes in the New Zealand pig-meat market. The evaluation of each individual equation in the model as well as the evaluation of the model itself has revealed some weaknesses in the model. These weaknesses limit the usefulness of the model as a policy tool and, at this stage, prevent the use of model forecasts as a policy instrument.

The first section of this chapter discusses the problems associated with the model in its present form. The second section briefly discusses the work currently underway to overcome these problems. This work should result in the re-estimation of the model in the next 12-18 months. Although these problems limit the usefulness of the model in its present form, the model described in this thesis does have a number of important applications. The final section discusses the usefulness of the model in its present form and briefly describes the way in which the model has been used over the last nine months. The application of the model over this period is evidence that this study has, at least partially, achieved the objective outlined above.

1. Chapter One, p.3

11.2 Problems Associated with the Model in its Present Form

The model described in this study has two main problems associated with it; the predictive ability of the farm price equations is poor and the parameter estimates of the supply equations are not entirely internally consistent. This section discusses the possible causes of these problems.

11.2.1 The Poor Predictive Ability of the Farm Price Equations

Although all of the farm price equations explain over 93 percent of the variation in farm prices, the predictive ability of these equations in the model is inferior to a naive no-change "model". This poor predictive ability impairs the performance of the other equations in the model. Discussion of the specification and evaluation of the farm price equations noted three problems that could prejudice the performance of these equations.

- (a) The influence of stock changes on the price for baconers was not found to be significant. Although it is possible that stock changes do not influence farm prices, Chapter Seven noted that:

"The result could also be due to data problems (i.e. a very poor estimation of buyers' actual change in stocks). Appendix A discusses the estimation of this variable in detail and noted that it was one of the least satisfactory variables in this study".²

If the 'change in stocks' series used to estimate the North Island baconer equation is a poor representation of the actual change in stocks, then the estimates in this equation will be seriously biased and the farm price equations

2. Chapter 7, p.151

will not adequately predict the effect of changes in supply and demand on farm prices.

- (b) The close association between the D20Q dummy variable and the 'anticipated trend production' variables may also impair the accuracy and stability of these two parameter estimates. This problem (i.e. collinearity with the D20Q dummy variable) may also affect other parameter estimates in the model.
- (c) Chapter Four discussed a generalised specification of the fresh pork market which simultaneously solved for the farm price of porkers. Unfortunately, because of data inadequacies, that specification had to be modified and individual porker price equations specified and estimated. Although the restrictions placed on fresh pork exports limited the problems caused by the re-specification this re-specification will probably distort the response of farm prices to a given exogenous shock. Further investigation is justified to find a reasonable way of regionally disaggregating all of the series used in the fresh pork equations.

11.2.2 Inconsistency of the Parameter Estimates in the Supply Equations

The parameter estimates in the supply equations for each island are not entirely internally consistent. In particular the parameter associated lagged porker price in the North Island baconer supply equation appears to be too large and results in a perverse long run relationship between a sustained increase in baconer (and therefore, porker) prices and baconer production. The substitutability between porker and baconer production in each island is also asymmetric.

This lack of consistency is a serious problem which constrains the policy application of the model and may act to bias model forecasts when the baconer/porker price ratio moves too far from its mean value. Given this problem, the model cannot be used to indicate to policy makers the effect of setting markedly differential farm prices for each weight range. The model response to a significant differential between these two prices may be an increase or decrease in the number of pigs in any one category without a corresponding decrease (increase) in the other category. This also implies that pigs are added or subtracted to the slaughter rate without a corresponding increase or decrease in herd size.

This problem could be a result of inadequate data; Appendix A noted that the porker farm price series for both islands were, along with the 'change in stocks' series, the least satisfactory in the database.

11.3 Developments Needed to Overcome Current Problems

It is obvious from the nature of the problems discussed above that the model needs to be re-estimated if these problems are to be overcome. However, a re-estimation of the model may not prove helpful in overcoming these problems until considerably more investigatory work is undertaken. This investigation should be undertaken at four levels:

- (a) To improve the 'change in stocks' and 'farm price for porkers' series in the database;
- (b) To provide enough a priori evidence to impose parameter restrictions on the D20Q variable in the model with the objective of adjusting production and consumption series used in the model and removing the D20Q variable from the model altogether;³

3. This is discussed in greater detail in Chapter Seven

- (c) To find a reasonable basis for regionally disaggregating all of the series used in the fresh pork equations so that this component of the model can be re-specified to move closely approximate the generalised simple equilibrium model described in Chapter Four;
- (d) To provide enough a priori evidence to impose parameter restrictions on the production equations in each island to ensure symmetry of price response. This should not prove too difficult and should, in combination with improved data for porker prices, enable a considerable improvement in the estimated production equations.

Most of the investigatory work currently underway is directed at improving the database, however some preliminary work at the other levels has been completed. Access to improved computer programmes should also aid the re-estimation of the restricted form of the model. Given current progress the model should be able to be usefully re-estimated in 12-18 months.

11-4 Applications of the Model in its Present Form

Although the model described in this study has a number of problems associated with it, it is still useful in its present form. This section discusses the potential applications of the model in its present form and the way in which the model has actually been applied to date.

11.4.1 Forecasting

The forecasting ability of the model was evaluated in Chapter Ten. That chapter concluded that, except for a limited number of variables (especially farm prices),

the model's forecasting ability was superior to naive forecasts both within and beyond the sample period. Although the forecasting ability of the model is likely to deteriorate as it is used for longer term forecasting beyond the sample period, the model is still useful if its role is confined to evaluating the impact of alternative scenarios rather than using the model to make long term predictions.⁴ In this latter case the errors in the forecast exogenous variables and the errors produced by the model will drastically reduce the confidence that could be placed on any long term prediction. This problem, combined with the lack of model accuracy in forecasting farm prices, means that the model should not be used to provide longer term (i.e. five to seven quarters in advance) price forecasts. Chapter Three indicated that accurate long term price forecasts would be an effective stabilisation instrument (i.e. that it would overcome the problems caused by imperfect information). However, given the problems currently associated with the model, it cannot be used for this purpose in its present form.

To date the model has been primarily used for short term (i.e. one period in advance) forecasting and to evaluate possible scenarios in the slightly longer term (e.g. three quarters in advance). For example, in mid 1980 Pork Marketing Board staff used the model to evaluate the impact on the consumption of pig-meat of a scenario where the real cost of feedgrains increased 10 percent and the Board maintained the farm price (BMP) at a level equal to eight times the per kilogram cost of feed grain. Feedgrain costs were assumed to increase linearly to 110 percent of their real 1980 (third quarter) level by the second quarter of 1981. The model results indicated that, under these assumptions (and "realistic" assumptions for the other exogenous variables),

4. Where predictions define the most likely outcome (i.e. exogenous variables are set at their "most likely" level) and scenarios define highly conditional outcomes (i.e. exogenous variables at a level that reflects alternative future scenarios).

total consumption of pig-meat would fall by nearly 10 percent by the second quarter of 1981 and, because farm prices have increased with respect to foreign prices, imports would increase. Given that the Board would be attempting to maintain an artificially high farm price (which would maintain domestic production) this reduction in consumption would result in considerable excess supply. In the absence of any other policy action on the part of the Board (e.g. a major promotional campaign to increase consumption) considerable quantities of pig-meat would therefore have to be purchased by the Board to maintain the 8:1 farm price : feedgrain cost ratio.

This sort of application of the model gives the Board an indication of its likely involvement in the market consistent with a given set of external circumstances (e.g. the feedgrain cost rise) and objectives (the maintenance of an 8:1 farm price : feedgrain price ratio). It also enables the Board to test the sensitivity of any forecast outcome to changes in other important exogenous variables (e.g. the cif cost of imports).

11.4.2 Policy Evaluation

The use of the simulation model to evaluate alternative policies is an example of highly conditional forecasting very similar to the scenario analysis described above.

"Policy variables" (which describe policy instruments) are set at alternative levels and the model generates alternative time paths for the endogenous variables. The major "policy variables" of interest to the Pork Marketing Board is the farm price of baconer and porker pigs in both islands. Although the model has not yet been used to evaluate the impact of alternative levels of BMP on the market, this sub-section discusses the use of the model for that purpose.

In order to evaluate the ability of the model to forecast the other endogenous variables when farm prices are determined exogenously, a final simulation was used to dynamically forecast the endogenous variables over the period 1971 (second quarter) to 1979 (second quarter) with farm prices set at actual levels. The results are reported in Table 11.1. Not surprisingly, these results represent

Table 11-1

Results of Final (Dynamic) Model Simulation from 1971
(second quarter) to 1979 (second quarter) with
Farm Prices Determined Exogenously

<u>Endogenous Variable</u>	<u>Theil U</u>	<u>MAPE</u>
PCS	0.27	5.7
XPTB	0.41	42.7
MPTS	0.81	134.8
PBN	0.50	4.9
PBS	0.40	3.6
PPN	0.59	5.7
PPS	0.39	5.6
PCN	0.48	10.2
DRPK	0.54	1.5
PCCP	0.55	5.0
DRBC	0.63	2.5
PCCB	0.42	3.9
DMP	0.83	2.6
DMB	0.82	3.4
CHST	0.43	78.8
XPTP	1.64	121.1

an improvement on previous model simulations where farm prices were determined endogenously. They indicate that, if farm prices could be exactly forecast, the other variables in the model (with the exception of XPTP) could be forecast with reasonable accuracy for as long as forecasts of farm prices (and other exogenous variables) were available.

The Board could use the model with exogenous farm prices to evaluate policies in two ways. Firstly it may be interested in how the behaviour of the pig-meat market would have changed if alternative levels of farm prices had been set by the Board during the sample period (i.e. a historical policy simulation). In this case the farm prices are set (exogenously) at alternative levels and alternative simulated time paths for the endogenous variables compared. For this type of simulation the restrictions on the export of fresh pork have to be lifted (i.e. with exogenously determined prices, the 'change in stocks' and 'fresh pork exports' volumes have to be able to adjust freely to bring supply and demand into balance). In fact the Board is likely to be particularly interested in the difference between the alternative stimulated time paths of these two equilibrating variables because they would act as proxies for the Board's own involvement in the market. For example, if the Board was to set BMPs at higher than the market determined farm price, then production and imports would increase and consumption and exports would decrease forcing both stocks and fresh pork exports to increase in the model.⁵ This increase in stocks and fresh pork exports would then be a measure of the quantity of cured and fresh pig-meat that the Board would have had to withdraw from the domestic market to maintain the farm prices at higher than market determined levels without incurring an immediate trading loss. This quantity would then have to be either removed from the local market (e.g. exported) which would probably

5. Assuming at this stage that the Board is not prepared to sell any of its own stocks at a loss. . /

involve the Board in a trading loss, or sold on the domestic market at a later date. The model could be used to determine the reduction in farm price (below market determined levels) needed at a later date to completely remove the Board's stocks. Using the model in this way would indicate to the Board the impact that alternative strategies (which would include combinations of alternative BMPs and alternative "disposal" policies) would have had on:

- (a) Production and consumption stability over the period; and
- (b) The breadth and depth of the Board's market involvement over the period (which could be calculated in terms of the Board's own income and expenditure).

However, historical policy simulation need not be restricted to identifying improvements in the operation of the present BMP scheme. It would be possible to use the model to evaluate a number of alternative stabilisation strategies in an effort to help the Board identify better strategies as well as improving its operation of current stabilisation policy.

Secondly, the Board may be interested in forecast policy simulation. In this case simulation analysis is applied to the model in the post sample period to generate alternative future time paths for the endogenous variables for alternative assumptions about the future time paths of the policy variables. The analysis would be very similar to that applied in historical policy simulation. The accuracy of this type of simulation is sensitive to the forecasts of the exogenous variables used as well as the sample accuracy of the model itself. However, the results of this type of analysis are likely to be very valuable to the Board in assessing the impact of alternative actions it may take on

both the market and its own income expenditure.⁶ This will assist the Board in setting its own policy as well as enlisting the support of Government agencies in supporting a given policy stance. Treasury is more likely to support the Board's involvement in the market if a reasoned assessment of both the likely effects and extent of this involvement can be demonstrated by the Board.

Although the model is applicable to the analysis of a wide range of policy questions, there are some questions which (given the problems associated with the model in its present form) the model should not be used to address. In particular, given the lack of symmetry in the production equations, the model cannot accurately simulate the effect of differential (farm) pricing policies.

Use of the model to evaluate alternative policies requires considerably more involvement of the policy maker than the use of the model to generate forecasts. Although the policy maker is required to specify the level(s) of the exogenous variables in both cases, this is considerably more difficult in the case of policy evaluation. In this case, alternative policies must be explicitly defined as alternative time paths of the exogenous (or exogenised) variables. In the pig industry this means that Pork Marketing Board staff must be able to define alternative levels for the BMP (and the associated stabilisation levy) as well as alternative "disposal" strategies (e.g. export, stock holding or even retail promotion). This involves quite a detailed consideration of the options available before the model is used. Although this is seen as one of the benefits of model use, it does imply considerable interaction between model users and policy makers. To date the Pork Marketing

6. The future policy simulation is not as sensitive to errors in the exogenous variables as long term predictions of market variables. Policy simulation is primarily concerned with the difference between the time paths of the exogenous variables with and without the influence of alternative policies rather than the absolute level of the endogenous variables at any particular future point in time.

Board has not used the model for policy evaluation. However, this reflects the relative inexperience of everyone involved in the use of the model rather than any faults in the model itself. The increasing use being made of the model should result in the eventual application of the model to policy evaluation.

11.5 Conclusion

The continued use of the model described in this study as a policy tool by Pork Marketing Board staff is an indication that this study has achieved the objective set out in Chapter One. Policy makers within the industry have found the model credible, useful and usable enough to continue using it as a policy tool and are interested enough in the potential of the model to continue funding its development. The use of the model to date for short term forecasting and medium term scenario evaluation has helped policy makers "anticipate and respond to problems facing the industry" over the last nine months. The continued application of the model should result in policy makers applying the model to evaluate alternative policies. Interest is already being shown in this application of the model. However, the model described in this study does have a number of problems associated with it which prevents its use as a policy instrument and limits its use as a policy tool. Further investigations currently underway should help to overcome these problems and extend the usefulness of the model. It is only when these problems are overcome that the full potential of the model can be realised.

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APPENDIX ATHE TIME SERIES DATAA.1 Introduction

This chapter describes each series used to estimate the model described in Chapter Four. The source of each series (or of the components of each series), are identified, the aggregation of series components is discussed, and the modifications thought necessary to maintain consistency within a series are made explicit. A description of each series used in the model is necessary for three reasons:

- (a) It is important that model users know precisely what each series represents. This is especially true when the series used in the model is an aggregation of other series;
- (b) It is important that the data used in the study is credible to potential model users. A careful description of the data enables the model user to develop an informed opinion about the accuracy and consistency of the data used. Where there are problems with the adequacy of the data, users should be aware of these problems in the interpretation of model output and should be aware of data inadequacy as a source of error in the estimation of the model;
- (c) A clear description of the data is essential if the model is to be regularly updated. An important objective of this study is to estimate a model of the pig-meat market that is useful to policy makers in the New Zealand pig industry. The model's usefulness is enhanced if the task of updating the model is made simpler at this stage.

The need to provide a clear description of the data used in the estimation of the model is enhanced in this particular study because of the number of unpublished series that have been used and because of discrepancies between some of the data used in this study and data published by the Department of Statistics.

A.2 Consumption, Production and Stocks

This section reviews the consumption, production and stocks figures used by the Department of Statistics, considers why these series are unacceptable and explains the deviation of new series for these variables.

A.2.1 The Department of Statistics' Figures

Although the Department of Statistics publishes estimates of the quantity of pig-meat produced and consumed in New Zealand on a quarterly basis¹ these figures have a number of serious problems associated with them.

- (a) Both series lapsed in September 1970 for three years so only annual estimates are available for the September years 1971, 1972 and 1973;
- (b) These series only describe aggregate production and consumption. No disaggregation by slaughter weight class or geographical region is available;
- (c) The production series is not comprehensive and therefore, in recent years, both production and consumption have been underestimated. Unlike other animals, more than half the pigs killed

1. Department of Statistics, Monthly Abstract of Statistics. See for example, MAS, November 1978, p.24 (Table 31).

in New Zealand are slaughtered at abattoirs. Unfortunately, the Department of Statistics collects slaughter figures from only 26 abattoirs whereas the Ministry of Agriculture and Fisheries (who also collect pig slaughter figures from abattoirs) collect pig slaughter figures from 32 abattoirs. The Department admits that no check has been made on the coverage of their survey for some years (the implication is that newly constructed abattoirs have not been included in the survey). The restricted coverage of the Department's production figures has resulted in an important underestimation of the pig kill. According to Ministry of Agriculture and Fisheries statistics, the proportion of the total kill going through abattoirs has increased from about 27 percent in 1968/69 to about 60 percent in 1972/73, with consistently more than 55 percent of the total pig kill handled by abattoirs since 1972/73. Table 5-1 compares the annual production of pig-meat series published by the Department of Statistics with a similar series based on Ministry of Agriculture and Fisheries figures.

- (d) The Department's production series includes an estimate of pigs killed on farms that is likely to distort fluctuations in the total quarterly kill. The weight of pigs killed on farms for human consumption is calculated from a five yearly survey of farm holdings. This annual survey figure remains constant between surveys and is divided by four to give quarterly estimates. It is doubtful whether this figure should be included in production for a study of this

Table A-1

Comparison of Annual Slaughter Statistics from
the Department of Statistics and the Ministry of
Agriculture and Fisheries (1971-1978)

<u>September Year</u>	<u>Total Production (000 Tonnes)</u>			
	<u>Department of Statistics</u>	<u>MAF*</u>	<u>Error</u>	<u>% Error</u>
1971	42.3	43.4	1.1	- 2.5
1972	40.6	42.2	1.6	- 3.8
1973	35.3	36.0	0.7	- 1.9
1974	34.4	38.2	3.8	- 9.9
1975	34.2	36.8	2.6	- 7.1
1976	32.8	38.3	5.5	-14.4
1977	39.0	43.9	4.9	-11.2
1978	38.2	42.8	4.6	-10.7

* Prior to 1975, this weight was calculated by applying the average weight to the total number of animals killed.

Sources: Department of Statistics, Monthly Abstract of Statistics, October 1979 (Table 10.4)

Ministry of Agriculture and Fisheries, Slaughter from Abattoirs and Export Works, (unpublished).

nature. Firstly, the estimate is unlikely to be reliable as an indication of the quarterly quantity of pig-meat killed on farms. Secondly, there is no variation in the figure between surveys (i.e. over five year periods) with discrete changes every five years. This pattern of variation is likely to give misleading results. Thirdly, changes in the quantity of pig-meat killed on farms is unlikely to have a significant impact on the pig-meat market. The 1977 Ministry of

Agriculture and Fisheries survey indicates that the number of pigs killed on farms for human consumption amounted to only slightly more than 1 percent of the total number of pigs killed. Given these considerations it was decided that, for the purposes of this study, it would be better to ignore this source of production and consumption than to use the five yearly survey figures as the basis for quarterly estimates of this variable;

(e) The consumption series has four major problems associated with it:

- (i) The production figure from which consumption is derived underestimates actual production;
- (ii) Consumption is calculated by subtracting pig-meat killed at export works and "destined for export" and any increase in pig-meat stocks away from the production figure. Imports are completely ignored. Although imports of pig-meat were insignificant up until the early 1970s, since that time imports have been a regular feature of the New Zealand pig-meat market. In some quarters, imports exceeded 10 percent of local production. Ignoring imports will tend to result in a further underestimation of the level of pig-meat consumption by the department's consumption series.

- (iii) Instead of subtracting actual exports from consumption, the department subtracts pig-meat killed at export works and "destined for export", as shown on the NZMPB tabulation. A note on this tabulation indicates that, although "destined for export", a quantity of this meat may actually be sold on the domestic market;
- (iv) As noted below, the Department's estimate of pig-meat stocks is incomplete.

The first three problems associated with the consumption series will all result in the department underestimating the actual level of pig-meat consumption;

- (f) The department's estimate of pig-meat stocks only includes stocks held at export works. There are two problems associated with this series. Firstly, the department's estimates are incomplete. It is difficult to estimate how important the stocks held outside export works are. Abattoirs are equipped with cold storage facilities which can only accommodate stocks for a maximum of 48 hours. However, bacon and ham manufacturers may hold relatively large quantities of cured pig-meat in stock. An indication of the size of stocks held by these manufacturers is given in the Census of Manufacturing for Industry 31114 - Ham, Bacon and Smallgoods Manufacturers. For the

three years from 1974/75 to 1976/77 "stocks at start (and end) of year" for all products for these manufacturers was approximately \$5 million. If the proportion of cured pork stocks to total stocks was the same as the proportion of cured pork sales to total sales (and this is pure speculation) then these manufacturers would have been holding approximately 1,000 tonnes of cured pig-meat as stocks. Changes in the level of these stocks could have an important impact on changes in the total level of stocks which typically vary between +/- 700-1,200 tonnes on a quarterly basis. Secondly, because a number of companies supply stock figures to the department in confidence, the stock series used by the department was not made available for use in this study. Therefore, an estimate of the department's series had to be made.

A.2.2 Derivation of the Series Used in This Study

Given all the problems associated with the Department of Statistics' production and consumption series they were considered unacceptable for use in a study of this type. Fortunately, the Ministry of Agriculture and Fisheries made their slaughter statistics available which enabled the construction of a production and consumption series that was both sufficiently accurate and sufficiently disaggregated for use in this study. This sub-section describes these new series as well as the procedure used to estimate the changes in the level of pig-meat stocks.

(a) Production

The Ministry of Agriculture and Fisheries slaughter statistics were used to describe the production of porker, baconer and chopper

meat for both islands. These statistics have the following advantages:

- (i) They have a better coverage than the Department of Statistics series. The Ministry of Agriculture and Fisheries statistics include all pigs killed at export works (for both local and export disposal), abattoirs and rural slaughterhouses. Compared to the Department of Statistics figures the Ministry of Agriculture and Fisheries statistics include the kill from an additional six abattoirs. For reasons outlined above, pigs killed on farms for human consumption have been ignored;
- (ii) They are consistently available from the fourth quarter of 1968 on a quarterly basis;
- (iii) They are available in sufficient detail to enable the total kill to be disaggregated both geographically and by weight range class;
- (iv) They are available on a more timely basis than the Department of Statistics figures.

However, the Ministry of Agriculture and Fisheries figures did require some adjustments:

- (i) The quarterly kill for each weight category for each island had to be estimated for the 1974 meat year from the quarterly island totals available. This was accomplished

by assuming that the proportion of the kill going into each category for each island was the same in each quarter of 1974 as it was in the respective quarter of 1975. (The change in the grading system occurred with the change to metrics in October 1973);

- (ii) Prior to the 1975 meat year, accurate figures are only available on a head slaughtered basis (i.e. the weight figures are incomplete). Calculations of the weight of pig-meat killed prior to 1975 was accomplished by multiplying each weight category by the average weight of pig killed in that category in 1975 (i.e. porkers 37.8kg, baconers 56.6kg, and choppers 98.6kg). Unfortunately the weight limits for each category were changed with the change to metrics in October 1973. This had two important effects, more pigs moved into the baconer (over 41kg) category and the average weight in both porker and baconer categories declined. The only way to account for this important change in grade classification is to introduce a dummy variable that will have a value of one for all observations from the fourth quarter of 1968 to the third quarter of 1973 inclusive and a value of zero thereafter. This variable will remove the error associated with using average killing weights that understate the actual average killing weights prior to 1974, and the error

associated with the change in the number of pigs classified as either pork or bacon;

- (iii) The figures for rural slaughterhouse kill were only available on a head basis by island. These figures were combined with the other kill figures by assuming that rural slaughterhouses killed porker, baconer and chopper pigs in exactly the same proportion with exactly the same mean weight as the combined export works and abattoir kill. These assumptions are not likely to introduce significant error into the calculations because rural slaughterhouses account for less than 1 percent of the total kill;

(b) The Change in Stocks

Despite the fact that they are incomplete and unavailable, the Department of Statistics estimate of the level of pig-meat stocks are the only estimates made and although it is impossible to estimate stock levels it is possible to estimate the change in stock levels implied by other figures published by the department. Given the methodology used in the department for calculating the level of consumption it is possible to estimate the change in stock levels used by the department by subtracting the quantity of pig-meat identified by the department as consumed and exported away from their estimate of the level of production. This methodology has two problems associated with it. Firstly, it makes the rather bold assumption that the exports figure reported in the trade statistics is the same as (or at least fluctuates in the same way as)

pig-meats "destined for export" recorded on the New Zealand Meat Producers' Board tabulation. To the extent that any meat classified as "destined for export" is actually sold on the domestic market, the adopted methodology will overstate the "change in stock" variable estimated by the department. Secondly, because the department did not publish quarterly production or consumption figures for the September years 1971-1973, interpolation of these quarterly values from the published annual figures need to be made. Quarterly interpolations for production and consumption for these years were made using average quarterly weights calculated from the published series.

This variable is, unfortunately, the least satisfactory variable in the model. After nine months use of the model policy makers in the pig industry are concerned to improve the information on stocks available to them. Efforts are also being made (by approaching companies directly) to improve the historical series on stocks so that better information is available when it becomes necessary to re-estimate the model. Information on stock levels from a number of large companies is compared with the values determined by the methodology noted above whenever the full model is used;

(c) Consumption

As noted in Chapter Four, pig-meat consumption is disaggregated in the model as either fresh or cured. Because virtually all imports and stocks are destined for the cured meat market, a quarterly series for the consumption of

fresh pork could be calculated by taking fresh meat exports away from the sum of porker and chopper production in both islands. A series for the consumption of cured pig-meat was calculated by subtracting the quantity of cured pig-meat exported and the change in stock estimate from the sum of pig-meat imports and baconer production in both islands.

A.3 Quantities and Prices of Imports and Exports

The Department of Statistics was able to supply figures for quantities and prices of both exports and imports of pig-meat on a quarterly basis. Export quantities and fob prices were available for both "pork" and "bacon and ham" categories from the quarterly trade statistics (External Trade of New Zealand) published as supplements to the department's Monthly Abstract of Statistics. Geographical disaggregation was not required.

Unfortunately the import statistics in these supplements are too aggregate to be able to identify pig-meat imports data. Figures for the quantity of pig-meat imported and the cif price of these imports were made available on a quarterly basis from the department's files. Most imported pig-meat is included in the "fresh, chilled or frozen" category with a minimal amount of imported bacon and ham but because virtually all pig-meat imports are processed within New Zealand no distinction between these categories has been made in this study. New Zealand "re-imports" have been included in the import totals; these imports constitute only a small proportion of total pig-meat imports. Geographical disaggregation was not required.

A.4 Population and the Consumer Price Index

Quarterly figures for the total population of New Zealand were taken directly from the Monthly Abstract of Statistics. The quarterly consumers price index (all groups) is taken directly from Price Statistics 1979 (previously the Prices, Wages and Labour Statistics) (p.13); "Consumers Price Index - Long Term Linked Series for all Groups, 25 Centres Combined (Base: December quarter 1977 = 1,000)."

A.5 Income

Unfortunately the Department of Statistics does not report a quarterly disposable income series and interpolating from the department's annual series (on the same basis as Yandle²) failed to yield sufficient income variation to give significant results. Probably the best indicator of the changes in quarterly income published by the department is the "Index Numbers of Nominal Weekly Wage Rates" published in the Prices, Wages and Labour Statistics. However, this is an index of the pre-tax income of wage and salary earners and is, as such, an inadequate description of personal disposable income. For the purposes of this study the total personal disposable income series compiled by the Reserve Bank of New Zealand for use in their model was used. This is a quarterly series which includes wage and salary payments (net of tax and taxation refunds), social security payments made by the Government, farm income (including the net result of farm income stabilisation), rent and interest receipts, company dividend payments, and income of the self employed minus the net effect of tax payments and refunds on "other persons". Although this series provides the best estimate of quarterly disposable income, it should be pointed out that some of the variation in this series has been removed because of the need to interpolate from annual figures for farm income, rent and interest receipts, the income of the self employed and company dividends.

2. C. A. Yandle, An Econometric Study of the New Zealand Meat Market, pp 167-169.

A.6 Retail Prices

Various issues of the Department of Statistics Prices, Wages and Labour Statistics supplied all of the retail price information. The retail prices for specific cuts of beef and mutton, and the retail prices of bacon and ham have been copied directly from this source. The price for poultry (roaster chicken) is copied directly from this source with prices shown in pounds (i.e. for prices published prior to 1975) converted to a price per bird by assuming an average weight per bird of 2.64lb.

The price indices for beef, mutton and pork are a weighted combination of the retail prices of specific cuts which form an index representative of the saleable portion of each animal.³ The weights used are identical to those used by Yandle⁴ except that Rolled Sirloin has been replaced by Porterhouse Steak in the beef index since the fourth quarter of 1972. The exact components and weights used in each index are:

<u>Mutton Index</u>		<u>Pork Index</u>	
Leg	0.2506	Leg	0.5448
Forequarter	0.4456	Chops (loin)	0.4552
Midloin Chops	0.3038		
Total	1.0000	Total	1.0000

Beef Index

Rolled Sirloin*	0.0899
Prime Ribs	0.1194
Rump Steak	0.0701
Blade Steak	0.4049
Mince	0.0503
Corned Silverside	0.2039
Sausages	0.0615
Total	1.0000

* Replaced by Porterhouse Steak from the fourth quarter 1972

3. For a good discussion of this technique see C. A. Yandle, op cit, pp 147-155
4. Ibid, Appendix C

Because porterhouse steak was approximately 27 percent more expensive than rolled sirloin the beef index actually used discounts the price of porterhouse steak by 27 percent before including it in the index.

For cured meats the approach suggested by Yandle was adopted:

"these two meats (bacon and ham) are treated as a single commodity, (the) retail price of each was therefore weighted to give a 'bacon and ham' retail price series. The meats were given equal weights (i.e. a simple average was taken) as they appear in approximately equal proportions in the baconer carcass. Because of the very high correlation between the retail prices of bacon and ham, the combination of the two into a single variable was statistically desirable, and did not result in a significant loss of information."⁵

The high correlation between retail bacon and ham prices noted by Yandle is still apparent.

As Yandle notes, the use of these cutting weights assumes that entire carcasses will be sold on the market.

A.7 Schedule (Farm) Prices

A correct schedule price for pig-meat is very difficult to determine for the following reasons:

- (a) Different livestock buyers offer different schedules for pig-meat at the same time. Fortunately, these schedules are highly correlated so it is possible to pick one schedule as being representative of the others;
- (b) Schedule payments are subject to a number of deductions (Pig Council levies, inspection

5. C. A. Yandle, op cit, p.152

fees, and insurances) and additional payments (headages and other incentive payments) that vary through time. One large co-operative pig buyer who supplied information for this study offered advance and deferred payments, special incentives for bulk suppliers as well as a return on the shares suppliers owned in the company. In deciding on what price is perceived by producers (i.e the price on which producers base production decisions) it is difficult to know exactly how to treat these "extra" payments and deductions. Considerable uncertainty is attached to some of them (e.g. headages which may be offered by one or two firms only for quite a short period). On the other hand producers may feel certain about receiving some payments but uncertain about the amount (e.g. deferred payments). Ideally, all of these "extra" payments and deductions should be taken into account but weighted by the degree of certainty that farmers attach to the level of each one. For the purposes of this study some assumptions about these weightings have been made based on discussions with people in the industry. Incentive payments are so uncertain that they have been discounted and deferred payments are likely to persist with some uncertainty about their levels. It was assumed that farmers expected current levels of deduction to continue into the future and that the deferred payments ruling in the previous year would be applicable to this year's kill.

- (c) . Different payments apply to the different quality grades of pig (e.g. prime, choice and standard). A perfectly rational producer

would weight the price for each grade by the number of pigs he expected to sell in each grade in order to arrive at a price for his "product". However, for the purposes of this study, the price for the top grade (i.e. prime) in each weight range was used instead of a weighted price for all grades. Lack of adequate information on the kill in each grade meant that the combined grade price was unlikely to yield better results than merely using the price for a single grade. As the schedule for different grades appears to be highly correlated, the use of a single grade schedule price is acceptable.

- (d) Alterations to the weight limits applied to the different grades, changes in the quality standards within weight ranges, and changes in the method used to calculate the weight of the slaughtered animal alters the farmers' return per pig without altering the schedule price per kilogram. Ideally, because the producer views his product as a live pig, these alterations should be reflected in a modified schedule price. However, the modification to the schedule price implied by changes in weight limits and quality standards is extremely difficult to determine. The distribution of the kill within each weight range and within each quality grade is unknown. This means that a calculation of the average gain or loss per kilogram implied by a change in weight limits and quality standards is reduced to a very rough estimation. Considering the error that could occur in making this type of modification to the

schedule price, no attempt to modify the schedule on these grounds was attempted. However, it is important to note that changes in weight limits and quality standards will introduce some error in the estimation of price response. On the other hand, the schedule price can be modified to account for changes in the method used to calculate the weight of the slaughtered animal. This type of change occurred twice during the period under consideration; when firms accepted "hot weight" as a basis of payment but made a deduction of about 10 percent for heads and feet and when the 10 percent deduction was discontinued. To account for these changes, the schedule was reduced by 10 percent for the period over which the deduction for head and feet was in force.

The discussion above illustrates the difficulties involved in calculating an appropriate schedule price from the schedule payments available from a number of firms. These schedule payments were collected from three large firms in the North Island and two large firms in the South Island and compared, where possible, with the Monthly Reports from Field Officers collected by the Pork Industry Council (these reports were only available from the fourth quarter of 1971). Although there was an attempt to get a good geographical coverage within each Island, the schedule prices are weighted heavily by Waikato prices in the North Island and Canterbury prices in the South Island. This was not considered to be a significant source of error because pig production from the Auckland region and the Canterbury region are highly correlated with pig production from the North and South Islands respectively (the respective correlation coefficients are 0.96 and 0.90). Because all of the firms who supplied information were mainly concerned

with processing, their pork weight schedules may not be fully representative of the prices offered to most pork weight pigs. Unfortunately firms specialising in the purchase of pork weight rather than bacon weight pigs were unable to supply information to this study. An investigation is proceeding to determine the extent of this possible source of error and to construct a more representative series for pork weight pigs to be used in model re-estimation.

In making the adjustments to schedule prices referred to in this section, the aim has been to approximate the farmers perceived return on live pigs so that the prices used should more accurately reflect the prices on which producers base production decisions and processors and wholesalers base costing decisions.

A.8 Margins

The margins between the farm price of porker and baconer pigs and the retail price of pork and 'bacon and ham' respectively were calculated by subtracting a volume weighted national farm price for each class of pig from the retail price for each class. The regional farm prices were aggregated by multiplying them by the proportion of the total kill supplied by each region in each quarter and summing. That is:

$$G_i = PR_i - \sum_{j=1}^2 W.PF_{ij} \quad i=1,2 \quad j=1,2$$

where:

$i = 1$ (for bacon), $i = 2$ (for pork)

$j = 1$ (for North Island), $j = 2$ (for South Island)

W = weight of pig-meat produced in class i from region j divided by total weight of pig-meat produced in class i .

G_i = margin for class i

PR_i = retail price for class i

PF_{ij} = farm price for class i in region j

Note that W_{ij} is endogenous.

A.9 Feed Costs

It is difficult to obtain an accurate index of feed costs faced by pig farmers because of the variety of feeds used. Chapter Two discussed the transition in the pig industry from dairy by-product to grain feeding and data presented in that chapter indicated the proportion of pig holdings on which grain, compounded rations, dairy by-products, garbage and "other" was fed to pigs. For the purposes of this study it was assumed that the quantity of garbage available for pig feeding and the real cost of this feed remained constant. It was also assumed that the real cost of dairy by-products available for pig feeding steadily declined (see the next section of this chapter). Given these two assumptions, feed costs can be adequately represented by the cost of grain based rations.

Despite the fact that most South Island producers who used grain based rations purchased barley and compounded a complete ration on the farm, the price of a proprietary compounded weaner-grower ration was used as a representative feed cost for both islands. This was considered reasonable because the cost of preparing a complete ration on the farm should be highly correlated with the cost of a proprietary compound feed.⁶ If the cost of feed barley only was used as an explanatory variable, the impact of variations in the cost of feed protein would be excluded. The use of a proprietary compound feed cost as a substitute for both purchased and farm mixed rations reflects an adequately weighted combination of all the costs incurred in the transportation, storage and preparation of animal feeds.

6. The variable cost of preparing a complete ration on the farm is virtually equivalent to the cost of the feed ingredients. The cost of the grain used in the feed (usually barley or maize or a mixture of these two) plus the cost of a protein supplement dominate the variable cost of the ration. For the North Island the compounded feed price was highly correlated ($R^2 = .80$) with the price of barley and meatmeal for the period from the fourth quarter 1971 to the first quarter 1979. The price of barleymeal accounted for most of the variation in the compounded feed price.

The price of compounded feed for both Islands was supplied by a single very large feed compounder and reflected the cost of this firm's weaner-grower ration in the Waikato (in the case of the North Island) and Canterbury (in the case of the South Island). These prices were compared with the price of compounded feeds reported in the Monthly Reports from Field Officers collected by the PIC and with written descriptions of the movement in grain and protein prices recorded in the Pork Industry Gazette and the Annual Reports of the Pork Industry Council.

A.10 Dairy By-Products Available for Pig Feeding

Although the real cost of dairy by-products has been assumed to remain constant, the quantity available for pig feeding has varied considerably and is likely to have had some influence on the supply of pig-meat for the first half of the period reviewed by this study. Unfortunately, although it is possible to obtain a reasonable estimate of the quantity of dairy by-product available it is impossible to know exactly how much of this by-product is fed to pigs, other classes of livestock, or wasted. Therefore, in calculating the quantity of dairy by-products available for pig feeding, it was assumed that pigs received a constant proportion of the total by-product available.

Dairy by-product is usually made available as a result of the cheesemaking process (i.e. whey) or as a result of the separation of wholemilk (either on the farm or at the factory) into cream and skim-milk for the manufacture of butter and other dairy products. The whey that is produced from cheese manufacture may be fed directly to livestock, the fat may be recovered to produce whey butter or the lactose may be extracted. The by-product available in each island from cheese manufacture was calculated using annual figures from the New Zealand Dairy Board's Schedule of Product Outputs of Dairy Companies and the Farm Production Reports for.

cheese, whey butter and lactose production. As figures for the 1978/79 season are unavailable, it was assumed that this season's production of cheese, whey butter and lactose was the same as the production for the 1977/78 season. Figures published by the New Zealand Dairy Board indicate that 0.36kg of whey powder and 0.03kg of whey butter can be produced for every kilogram of cheese manufactured.⁷ It was assumed that whey powder had approximately half the feeding value of skim-milk powder,⁸ and that whey with the lactose removed had a nil feed value.⁹ The dairy by-product (in units of skim-milk powder equivalents) available from cheesemaking in any one year was calculated as the whey powder that could have resulted from the cheese production in any one season minus the lactose and whey powder actually produced, plus the whey butter that could have resulted from the same cheese production minus the whey butter actually produced all divided by two.¹⁰ The figures derived from this calculation may overstate the actual by-product available because, unless whey powder production was clearly identified as such in the Schedule (rather than merely called "other powders"), it was ignored. The yearly production totals were broken down into quarterly production figures using the proportion of milkfat processed in dairy factories in each quarter for each island and each year as an indication of the distribution of by-product availability throughout the year.

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7. New Zealand Dairy Board, Dairy Industry Information at a Glance, 1977, p.21.
 8. National Academy of Science, Nutrient Requirements of Swine, Nutrient Requirements of Domestic Animals Number 2, 7th Edition, Washington DC, USA, Revised 1973. Pages 36 and 37 of this publication have the composition of both whey powder and skim-milk powder. Although whey powder only has 41 percent of the protein contained in skim-milk powder it has 82 percent of the energy content (both on a dry matter basis). It was therefore assumed that whey powder had about 50 percent of the feed value of skim-milk powder.
 9. Murray Hollard pers. com.
 10. The exact equation used was:

$$(\text{Cheese production} * 0.36167 - \text{Lactose} - \text{Whey Powder} + \text{Cheese production} * 0.03 - \text{whey butter}) / 2 = \text{bi-product available in SIMPE.}$$

The calculations needed to identify the quantity of dairy by-product available from the separation of whole-milk were significantly more complicated. For the South Island the calculations were reasonably straight forward because South Island dairy factories produced a relatively narrow range of products. Figures published by both the New Zealand Dairy Board¹¹ and Dolby, Creamer and Elley¹² indicated that the production of 1kg of butter will result in the production of either 1.5275kg of skim-milk powder and 0.0932kg of butter-milk powder, or 0.5343kg of Casein, 0.0932kg of butter-milk powder, and 1.1423kg of Casein Whey Powder. The dairy by-product (in units of skim-milk powder equivalents) available in the South Island from separated whole-milk was calculated as the skim-milk powder that could have resulted from the butter production in any one season minus the skim-milk powder and casein (converted to skim-milk powder equivalents) actually produced, plus the butter-milk powder that could have resulted from the butter production in any one season minus the butter-milk powder actually produced, plus the casein whey powder (in units of skim-milk powder equivalents) that could have been produced from the casein actually produced.¹³ No casein whey powder was actually produced in the South Island over the period covered by the study. Butter, butter-milk powder, skim-milk powder and casein production for the South Island was found in the Schedule of Product Outputs of Dairy Companies and the annual production totals divided into quarterly production figures using the same method used in calculating quarterly whey production. The by-product from separated milk figure for the 1978/79 season was assumed to

11. New Zealand Dairy Board, "Dairy Industry Information at a Glance", 1977, p.21
12. Dolby, R. M., Creamer L. K., and Elley, R., "Effect of Payment on Fat plus Protein on Payout to Individual Suppliers of a New Zealand Dairy Company", New Zealand Journal of Dairy Technology, Volume 4, No. 2, June 1969. New Zealand Dairy Research Institute, Palmerston North, p.46-54.
13. The exact equation used was :
$$\frac{\text{butter} \times 1.5275 - (\text{skim-milk powder} + 2.859 \times \text{casein})}{\text{butter} \times 0.0932 - \text{Butter-milk powder}} + \text{casein} = \text{bi-product available from whole-milk separation in skim-milk powder equivalents.}$$
 Casein whey powder is assumed to have

be 2 percent below the same figure for 1977/78 (this is based on the assumption that production of this by-product in total fell in exactly the same proportion as production of this by-product on-farm - i.e. the same as on-farm separation of whole-milk). It should be noted that the figure calculated above for the South Island includes the skim-milk resulting from on-farm separation of whole-milk.

A similar approach to the one used above for the South Island was used to calculate the by-product from whole-milk separation in the North Island. However, this approach was complicated by the fact that North Island dairy factories produced a very wide range of products (e.g. in the 1977/78 season North Island factories produced 26 products (not including different types of cheeses) other than those noted for South Island companies, this included three categories called "other products", "other powders", and "mixes" in the earlier years a considerable amount of production was classified as "other powders".) Throughout the period covered by the study these products claimed a significant proportion of total production. From the information published by the New Zealand Dairy Board¹⁴ and by Dolby, Creamer and Elley¹⁵ an estimate of by-product available from separated whole-milk was made from the production figures for butter, skim-milk powder, casein, butter-milk powder, casein derivatives (including casein whey powder), whole-milk powder, frozen cream, anhydrous milkfat, and skim-milk cheese and concentrate. These products were the most important of the additional products produced by North Island factories and were able to be incorporated into the by-product calculations. Two problems were associated with this calculation; firstly, there is a larger margin for error because of the number of products involved and the number excluded, and secondly, the calculations did not produce a very credible result.

14. New Zealand Dairy Board, op cit

15. Dolby, Creamer and Elley, op cit

It is widely accepted that dairy by-products declined as a source of pig feed throughout the period under review. Data presented in Chapter Two indicates that only 15 percent of all producers feed more than 60 percent dairy by-products and that these producers are reasonably evenly distributed across the different herd sizes. One of the problems with the series discussed above is that although it indicates a continual decline in by-product availability for most of the period, it also indicates that by-product availability rose sharply in the 1976/77 season and that this increase was sustained into the 1977/78 season. These figures indicate that the level of dairy by-product availability in 1976/77 was similar to that in 1972/73. Not only are these results in sharp contrast to the accepted view, but they are also in sharp contrast to figures supplied by the Dairy Board showing the amount of cream supplied to dairy factories in the North Island (i.e. the amount of on-farm separation of whole-milk). Finally, the results suggested by the calculations described above indicate that the total quantity of butterfat fed to livestock in New Zealand is significantly in excess of the figures reported in the Dairy Board's Farm Production Reports for the early 1970s. In light of the problems associated with this calculation it was decided to use the amount of by-product resulting from the on-farm separation of whole-milk as representative of the by-product available from both on and off-farm separation of whole-milk in the North Island. In order to express this by-product in skim-milk powder equivalents, the quantity of cream supplied to dairy factories in the North Island was multiplied by 0.743.¹⁶ The resulting figures gave a credible picture of the decline in dairy by-product availability from separated whole-milk. Annual figures were converted into quarterly figures using the same method applied to whey production.

16. The Dolby, Creamer and Elley Study indicated that 1kg of cream produces 7.709kg of skim-milk which (with a 98 percent recovery and 3.5 percent moisture) is equivalent to 0.743kg of skim-milk powder.

In an effort to remain consistent in the study and to simplify the task of data collection associated with operating the model the figures for by-product production from the on-farm separation of whole-milk for the South Island were also calculated and compared with the more comprehensive series for total by-product production from whole-milk separation. Fortunately, the more limited series gave a very good indication of the variability in the total series for the South Island. Therefore, the simpler calculation of dairy by-product production from the on-farm separation of whole-milk was used as a substitute for total by-product production from whole milk for both North and South Islands.

A.11 Nominal Weekly Wage Rate

The Department of Statistics "Index of Nominal Weekly Wage Rates - Adult Male Employees : Part Three Rates Within the Jurisdiction of All Determining Authorities" published in the Prices Wages and Labour Statistics was used to reflect the opportunity cost of labour in the farm production functions.

A.12 Marketing Costs - Butchers Wage Rates

Given the importance of butchers' wage costs in total marketing costs, these wage costs have been used in a number of studies as a substitute for marketing costs.¹⁷ Yandle used an annual index of minimum average weekly wage rates for a weighted combination of three types butchers employee and interpolated to give quarterly observations.¹⁸ He noted that:

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17. See, for example, C. A. Yandle, op cit, Chapter 5; G. R. Griffith, "Sydney Meat Marketing Margins - An Econometric Analysis", Review of Marketing and Agricultural Economics, Volume 42, No.4, December 1974 pp226-227; E. R. Arzac and M. Wilkinson, "A Quarterly Econometric Model of United States Livestock and Feed Grain Markets and Some of Its Policy Implications", American Journal of Agricultural Economics, Volume , No. , May 1979, p.300.
 18. C. A. Yandle, op cit, p.170

"each of the three indices (for each employee type) varied little from the other two. Thus the effect (of the weightings) on the final index was slight."¹⁹

For the purposes of this study information on the award wage rates of three classes of employee in the New Zealand Butchers' Award (i.e. first bacon curer, journeyman butcher, and Grade 1 worker) was collected along with the piecemeal rate for pigs published in the Meat Processors, Packers and Preservers, Freezing Works Award to represent marketing costs at the retail and wholesale level respectively. The rates published in these awards were then adjusted for General Wage Orders. As the collection of these series was tedious and would have added considerably to the cost of operating the model, they were compared with the objective of identifying one rate which was indicative of the movements in all the rates available. Fortunately the journeyman butchers award wage rate (applied to butchers who had completed the apprenticeship) acted as a good substitute for movements in the other rates. Therefore, the journeyman butchers rate was selected for use in the model. These wage rates are minimum rates with charges recorded as at the date a new award was announced (rather than the date they became effective which would have implied that employers would correctly anticipate backdating of award changes). To the extent that payments in excess of award rates are made, the award rate will not correctly reflect butchers' wage costs. However, these rates should indicate the general movement in butchers wage costs.

A.13 Interest Rates

The "Three Month Secured Deposits with Finance Companies" published in the Reserve Banks Bulletin²⁰ was used as an

19. Ibid, p.170

20. Reserve Bank of New Zealand, Bulletin, August 1979, p.318 and December 1976 p.379.

indication of the opportunity cost of funds tied up in processors and wholesalers quarterly stocks of pig-meat. When a spread of rates is published by the Reserve Bank for any particular quarter the higher rate has been used.

A.14 Conclusion

In this chapter the source of each series, the methodology used to convert each series into an appropriate form, and the weaknesses of the data available to estimate the model have been discussed. This discussion is particularly important because of the number of important series that were not available in a usable form ^{from} published statistics and therefore had to be collected from primary sources. Without the assistance of a considerable number of people in the industry and in Government departments the estimation of the model outlined in Chapter Four would have been impossible.

Although most of the data collected for this study are of high quality there are two important weaknesses in the data; both the "change in stocks" series and the porker schedule series for both islands need improvement. Model users have been made aware of these problems and work is currently in progress to improve both series.

Because most of the unpublished series were made available on a confidential basis, the actual data used in this study is not presented here.